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HE MINERALOGICAL MAGAZINE
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etasomatism associated with the greenstone-hornfelses of Kenidjack and Botallack, Cornwall.

(With Plates VI and VII.)

By C. E. Tilley, Ph.D., B.Sc.
rofessor of Mineralogy and Petrology, University of Cambridge.

[Read June 6, 1935.]

N a paper entitled 'Hornfelses from Kenidjack, Cornwall'[1] the nature and origin of the rock types characterized by anthophyllite d cummingtonite occurring in the aureole of the Land's End granite re discussed.

Since these rocks were investigated in 1928 the writer has extended study of them both in the field and in the laboratory, with the ult that further light on the origin of these rock types has been tained. It is the purpose of these notes to examine in more detail evidence which is considered to add to their understanding. In Kenidjack paper the petrography of the rocks was described at ne length and in the present paper petrographic data will be given ly in so far as they supplement the previous account, which may be nsulted for a detailed statement.

The contact altered greenstones.

The greenstones at Kenidjack are known only in their contact ered state. In the Kenidjack paper their mineralogical composi- n was described but hitherto no chemical data on these rocks have

[1] C. E. Tilley and J. S. Flett, Summ. Progr. Geol. Surv. Great Britain, 1930, 1929, pt. 2, pp. 24–41, hereafter referred to as the Kenidjack paper. A. 4–402.]

been presented. The account now given supplies this deficiency The rocks are essentially hornblende-plagioclase types. Prior to contact metamorphism they had been subject to shearing and dynamic metamorphism so that banded types are prevalent among them This fact had been realized long ago by Allport[1] in his description o these rocks in 1876, and has been emphasized both in the account in the Survey Memoir and in the Kenidjack paper. Though there is considerable variation in the relative proportions of the component minerals, the mineralogy is comparatively simple, the variety being dominated by the relative proportions of green hornblende and plagioclase. It is true that hornfelses occur among them containing grossular, epidote, diopside, and axinite, yet these types are comparatively uncommon in the coastal region between Kenidjack and Botallack dealt with in this paper.

TABLE I. *Analyses of hornfelses and cummingtonite.*

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
SiO_2	40·25	49·10	58·15	48·87	47·07	33·58	52·60	51·15	53·55	53·1
TiO_2	2·65	1·20	1·85	2·71	2·12	2·96	1·85	2·20	0·40	0·2
Al_2O_3	17·22	10·54	12·95	16·71	20·20	11·79	20·64	16·42	8·40	2·7
Cr_2O_3	—	—	—	0·01	0·02	—	—	—	—	—
Fe_2O_3	1·88	0·87	trace	0·13	trace	11·27	0·20	4·42	0·74	0·2
FeO	11·16	10·27	10·76	12·85	12·73	17·50	7·66	11·91	26·75	22·4
MnO	0·24	0·17	0·12	—	0·11	0·21	trace	trace	0·25	0·2
MgO	7·78	10·72	6·44	9·60	10·09	15·55	5·02	3·92	2·37	15·4
CaO	14·82	14·00	7·05	5·42	2·14	0·89	2·45	1·50	1·20	2·2
Na_2O	1·20	1·22	1·02	1·61	1·48	0·60	2·28	3·57	0·26	—
K_2O	0·97	0·10	0·14	0·27	1·97	0·32	4·73	2·83	2·94	—
H_2O+	0·90	0·90	0·60	0·99	1·50	4·60	1·80	1·60	2·15	3·3
H_2O-	0·20	0·10	0·50	0·07	0·16	0·13	0·40	0·30	0·65	—
P_2O_5	0·65	0·78	0·49	0·50	0·12	0·36	0·40	0·04	0·06	—
CO_2	nil	nil	nil	0·07	—	nil	nil	nil	nil	—
	99·92	99·97	100·07	99·81	100·21	99·78	100·03	99·86	99·72	100·1
Sp. gr.	3·203	3·031	2·982	2·966	2·907	3·041	2·819	2·916	3·019	—

No. 5, also FeS_2 0·47, Li_2O 0·03. No. 6, also Cl 0·02, F nil.

1. Greenstone-hornfels, Carn Kenidjack. Analyst, W. H. Herdsman. Gree hornblende, small amounts of colourless augite, plagioclase (replaced by whit mica), ilmenite, sphene, and apatite.

2. Greenstone-hornfels, Zawn a Bal. Analyst, W. H. Herdsman. Bands o green hornblende, alternating with plagioclase bands containing accessor ilmenite, sphene, and apatite.

3. Cummingtonite-plagioclase-hornfels, North Zawn quarry. Analyst, W. H Herdsman. Plagioclase (Ab_1An_1) with some anthophyllite, quartz, cordierite biotite, ilmenite, and apatite.

[1] S. Allport, Quart. Journ. Geol. Soc. London, 1876, vol. 32, p. 407.

4. Cummingtonite-anthophyllite-cordierite-plagioclase-hornfels, coast between rth Zawn and Wheal Edward Zawn, Kenidjack (with ilmenite and biotite). alyst, B. E. Dixon, Summ. Progr. Geol. Surv., 1930, for 1929, pt. 2, p. 32.

5. Anthophyllite-cordierite-hornfels, Carn Kenidjack (with biotite, plagioclase, enite, and some cummingtonite). Analyst, B. E. Dixon, Summ. Progr. Geol. rv., 1930, for 1929, pt. 2, p. 28.

6. Anthophyllite-cordierite-(clinochlore)-spinel-diaspore-hornfels, Inner quarry, midjack (with magnetite, ilmenite, apatite, and biotite). Analyst, R. Sutcliffe, mm. Progr. Geol. Surv., 1930, for 1929, pt. 2, p. 33.

7. Cordierite-biotite-hornfels, Zawn a Bal, Botallack. Analyst, W. H. rdsman. Cordierite, biotite, quartz, oligoclase-albite, ilmenite, rutile, apatite, sscovite.

8. Cordierite-biotite-hornfels, Zawn a Bal, Botallack. Analyst, W. H. rdsman. Cordierite, biotite, quartz, albite-oligoclase, ilmenite, magnetite, atite.

9. Grunerite-biotite-hornfels, Zawn a Bal, Botallack. Analyst, W. H. rdsman. Grunerite, biotite, quartz.

10. Cummingtonite from cummingtonite-biotite-cordierite-hornfels, Rifle nges, Kenidjack. Analyst, R. Sutcliffe. Water below 105° C. not separately ermined. Sign and elongation positive, optic axial plane parallel to (010). tinction $\gamma : c = 19°$, refractive indices α 1·643, γ 1·670. Analysis corresponds $(OH)_{3\cdot2}(Ca,Fe,Mg,Mn,Ti)_{6\cdot5}(Si,Al)_8O_{22}$. Summ. Progr. Geol. Surv., 1930, for 29, pt. 2, p. 31.

To determine the range of chemical composition amongst these eenstones, two varieties have been chosen for analysis. In the one, e dominant mineral is green hornblende; in the other, hornblende d plagioclase form alternating bands. These two types may be ken as representing the prevalent varieties among the greenstones the area. A hornblende-rich type from Carn Kenidjack chosen for alysis gave the result under 1, table I. Green hornblende is the minant mineral forming more than 80% of the rock. The mineral optically negative, $\gamma : c = 19°$, and has β 1·678. The remaining nstituents are granules of colourless augite, ilmenite, sphene, and all amounts of plagioclase now partly replaced by white mica 1·586). The analysis makes it clear that this hornblende must be highly aluminous type. A hornblende with high Al_2O_3 (16·75%) s already been recorded by J. A. Phillips[1] from the greenstones of e Botallack cliffs.

The second rock (analysis 2, table I) comes from the promontory the north side of Zawn a Bal. In this, bands rich in green horn-nde alternate with bands composed of plagioclase and ilmenite . 1). Granular sphene in part replaces the ilmenite. The horn-nde is optically negative, $\gamma : c = 19°$, and has β 1·650. The plagio-

[1] J. A. Phillips, Quart. Journ. Geol. Soc. London, 1876, vol. 32, p. 167.

clase bands contain a minutely granular plagioclase of composition Ab_1An_3, β 1·569, with streams of ilmenite partly replaced by sphene, together with minute granules of apatite. The modal composition of the rock is green hornblende 64, plagioclase 30·5, ilmenite, magnetite, and sphene 3·5, apatite 2%. In contrast with the hornblende of the first rock the hornblende of this greenstone-hornfels must be practically free from alumina, as the rock itself contains only 10·54% Al_2O_3. The low silica percentage of the Carn Kenidjack greenstone-hornfels is accounted for by the replacement of silicon by aluminium in the constitution of its dominant amphibole.

In table II the analyses of these two hornfelses are set down together with comparative analyses. The principal distinguishing feature of the analyses is the high lime percentage and low soda figures. Comparable figures can be found amongst existing analyses of basic igneous rocks but it seems probable that these greenstones may have suffered some enrichment in lime during the shearing (and segregation) to which they have been subject prior to contact metamorphism.

TABLE II. *Analyses of type varieties of greenstone, with comparative analyses.*

	1.	1*a*.	2.	2*a*.	2*b*.	2*c*.	3.
SiO_2 ...	40·25	42·08	49·10	48·72	49·75	48·70	44·6
TiO_2 ...	2·65	2·26	1·20	1·04	4·60	2·41	1·9
Al_2O_3 ...	17·22	16·04	10·54	11·75	12·18	12·61	13·8
Fe_2O_3 ...	1·88	5·93	0·87	1·44	0·03	3·26	1·3
FeO ...	11·16	8·75	10·27	6·63	9·88	5·65	10·7
MnO ...	0·24	0·32	0·17	0·45	0·48	0·03	0·2
MgO ...	7·78	6·95	10·72	10·92	9·54	8·49	9·2
CaO ...	14·82	12·66	14·00	16·45	11·79	13·38	14·4
Na_2O ...	1·20	1·88	1·22	0·96	1·19	2·46	1·2
K_2O ...	0·97	0·93	0·10	0·10	0·11	0·63	0·5
H_2O+ ...	0·90	2·76	0·90	1·28	0·35	0·90	0·9
H_2O- ...	0·20	—	0·10	0·06		0·10	0·1
P_2O_5 ...	0·65	0·34	0·78	0·30	0·06	0·36	0·7
CO_2 ...	nil	—	nil	nil	—	0·97	nil
	99·92	100·90	99·97	100·40	99·96	99·95	99·9

1. Greenstone-hornfels, Carn Kenidjack.

1*a*. Basalt, Mindello, Cape Verde Islands. (H. S. Washington's Tables, 191 p. 656.)

2. Greenstone-hornfels, Zawn a Bal, Botallack.

2*a*. Gabbro, Kalgoorlie, Western Australia. (H. S. Washington's Table 1917, p. 704.) Also FeS_2 0·24, V_2O_3 0·06.

2*b*. Hornblende-schist, Yarikita Hill, British Guiana. (J. B. Harrison, Pub Imp. Bureau Soil Science, Harpenden, 1934, p. 31.)

2*c*. Greenstone (lava), Mesket formation, NE. of Lake Seimajaure, Swedi Lapland. O. Kulling, Geol. För. Förh., 1933, vol. 55, p. 326.

3. Greenstone-hornfels, mean of analyses 1 and 2.

Reference has already been made to the shearing the greenstones suffered prior to thermal alteration. Original structures are rarely to be met with, but an exception is provided in the cliff section on the south-west side of Kenidjack cliff where pillow structures are to be recognized (pl. VII, fig. 4). Here good exposures of pillow lavas are to be found over a small area. The pillows range in size upwards from a foot in diameter to two feet or more. They have in places siliceous material forming the interspaces between the pillows. The material of the pillows has suffered radical changes in composition. Granules and streams of ilmenite persist, but hornblende may be entirely absent. In one type hornblende is confined to grains $\frac{1}{2}$–$\frac{3}{4}$ mm. in diameter set in a base of biotite and plagioclase; and in some pillows hornblende has completely disappeared, the pillow being made up of nests of secondary quartz, muscovite with some chlorite and/or biotite, set in a groundmass composed almost wholly of biotite with a little plagioclase. The nests stand out as excrescences on the weathered surfaces. It is clear that the original lavas have suffered extensive metasomatic change with loss of lime and enrichment in silica.

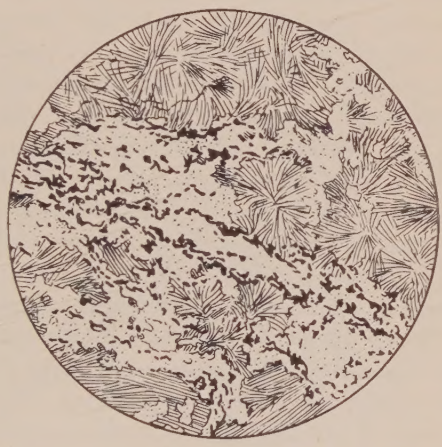

Fig. 1. Greenstone-hornfels, Zawn a Bal. Green hornblende, plagioclase, and streams of ilmenite.

The material in the interspaces between the pillows is usually quartzose—built up of quartz with some green hornblende, or quartz with biotite, muscovite, and oligoclase. Some interstitial material is composed wholly of green hornblende (γ 1·655, $\gamma : c = 19°$).

In the Kenidjack paper the intimate association of the anthophyllite- and cummingtonite-bearing rock types with the typical greenstones was stressed, and evidence was presented for the view that these rock types were derived from the greenstones. The results of further study all go to show that this view of their origin is the only one which is in harmony with the field evidence and the laboratory

examination. The greenstones were believed to have suffered in part intense weathering whereby lime was leached out of the weathered products and these on contact metamorphism gave rise to the variety of rock types bearing anthophyllite, cummingtonite, and cordierite.

There can be no doubt that these hornfelses have been derived from the greenstones by an essential leaching of lime from them, but the writer's more extended field and laboratory study has led him to modify his previous view as to the time when this removal of lime took place. In brief, it is now believed the greenstones have suffered this loss of lime during the period of contact alteration as a result of the passage of solutions eventually derived from the granitic magma, solutions which eventually gave rise to the rich tin and copper deposits which characterize the Botallack area. Before, however, the character of this replacement is discussed in detail the mineralogical and chemical changes which can be traced through the various mineral assemblages from the greenstones will be briefly reviewed.

It has already been remarked that banded greenstone-hornfels are the characteristic contact rocks with which the anthophyllite and cummingtonite rocks are associated. It is particularly in the preservation of this banding and of the essential textural features that the chemically contrasted rock types resemble one another.

The essential mineralogical changes which can be traced through from the greenstones are the five following:

1. *Incoming of biotite.*—Here a light brown coloured biotite appears amongst the green hornblende fibres partly replacing them, but this mineral also appears in the plagioclase bands. In other respects the texture of the greenstone-hornfels is unchanged.

2. *Appearance of spinel and diaspore.*—A rarer type of change is the appearance of pleonaste with or without diaspore in the plagioclase areas or near their contact with the green hornblende areas. A palimpsest feature not uncommonly met with is the preservation of the characteristic ilmenite streams passing unresorbed through the spinel areas. Diaspore is often associated with the spinel and is then frequently accompanied by almost colourless clinochlore forming a fringe to the diaspore grains as if the conditions permitting the formation of diaspore were favourable to the formation of clinochlore. Corundum has not been met with in these hornfelses, nor does it appear ever to have been present. Examples of greenstone-hornfelses carrying spinel and diaspore with associated clinochlore have been figured in the Kenidjack paper (pl. II, figs. 5 and 6).

3. *Appearance of cummingtonite and anthophyllite.*—The intimate relation of the ferromagnesian amphibole types with the true greenstones is shown by the transition of these rock types one into the other. The commonest rock type showing this transitional relationship is a cummingtonite-plagioclase type. These cummingtonite-

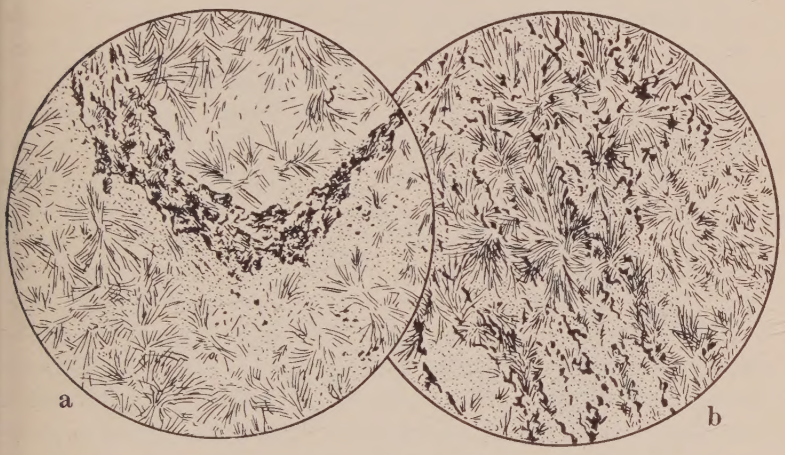

Fig. 2*a*. Banded anthophyllite-cordierite-plagioclase-hornfels rich in quartz, Carn Kenidjack. Anthophyllite with some cummingtonite, quartz (clear areas), plagioclase, and bands of plagioclase and cordierite enclosing abundant ilmenite.

Fig. 2*b*. Cummingtonite-plagioclase-hornfels, North Zawn quarry. Cummingtonite, plagioclase, and streams of ilmenite; some interstitial cordierite and quartz.

plagioclase-hornfelses (with or without biotite) present the same textures as those of the greenstones proper (fig. 2 *b*). The cummingtonite and plagioclase bands of the former represent in essentials the green hornblende and plagioclase bands of the latter. The streams of ilmenite and minute granules of apatite so characteristic of the normal greenstones are preserved intact in the cummingtonite-hornfels. The cummingtonite and plagioclase may be accompanied by biotite, and quartz often appears among the plagioclase grains. Anthophyllite may appear together with the cummingtonite, but it usually becomes prominent only when cordierite is developed (fig. 2 *a*).

4. *Appearance of cordierite.*—The incoming of cordierite brings us to the dominant types of chemically altered hornfelses which can be traced back to a greenstone parentage. The petrography of these rocks has been given in some detail in the Kenidjack paper. The

cordierite development belongs characteristically to the plagioclase areas, and it appears that by replacement of plagioclase, cordierite increases in amount in these rocks (figs. 3 *a* and 3 *b*). In this change the streams of ilmenite and granules of apatite persist as a relict feature, appearing as they often do enclosed in large twinned cor-

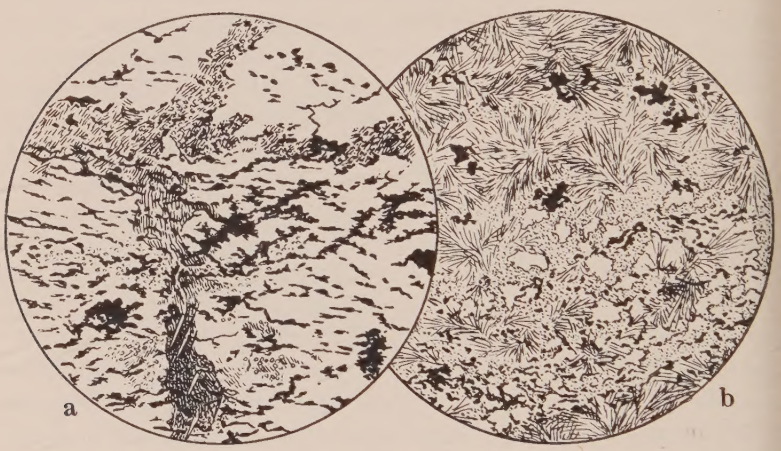

Fig. 3*a*. Anthophyllite-cordierite-hornfels, Carn Kenidjack. Cordierite forms the colourless groundwork in the form of coarse-grained crystals through which pass streams of ilmenite. These are separated by threads of biotite with a crystal of anthophyllite at the bottom of the figure.

Fig. 3*b*. Anthophyllite-cordierite-plagioclase-hornfels, Carn Kenidjack. Anthophyllite, cummingtonite, cordierite, plagioclase, and ilmenite. The clear areas are cordierite extinguishing as a unit.

dierite crystals of the anthophyllite-rocks. A fine example of this texture is figured in the Kenidjack paper (pl. I, fig. 6).

It is to be noted that the development of cordierite corresponds to a stage when all green hornblende has disappeared from the rock.[1] There is clearly a tendency, when much plagioclase is still present, for the dominant amphibole to be cummingtonite, the orthorhombic anthophyllite being more typically associated with the cordierite-

[1] A. L. Hall and G. A. F. Molengraaff (Verh. Akad. Wetenschappen, Amsterdam, 1925, vol. 24, no. 3, pp. 128–131) have recorded the association cordierite-actinolitic hornblende in amygdules and in the body of a basic igneous rock—the basal amygdaloid of the Vredefort area. Some doubt may be expressed on this reported co-existence of cordierite and hornblende, and it may be questioned whether a cordierite-cummingtonite or anthophyllite association is not indicated. A further genetic study of this unusual occurrence would be of interest.

bearing rock types. Where the chemical changes have been such as to lead to a deficiency of silica, the cordierite is accompanied not infrequently by spinel with or without diaspore.

5. *Eventual disappearance of amphibole.*—In the previous study the anthophyllite-cordierite-rocks were regarded as the extreme variants from the greenstone proper. The present study has shown, however, that more particularly at Botallack rock types are developed which must be regarded as further variants derivative of the greenstones.

These rocks are essentially cordierite-biotite-hornfels in which no amphibole is developed. Their finest exposures are to be met with on the promontory between Zawn a Bal and De Narrow Zawn south of The Crowns, Botallack. The rocks are characteristically dark to reddish-brown in hand-specimens, due to the development of abundant fine-grained iron-ore and biotite.

They are closely associated with the greenstones and anthophyllite-rocks, passing into them both across and parallel to the prevalent banding. These rocks weather with rough excrescences formed of cordierite or quartz and plagioclase. Many of them as seen at Zawn a Bal are extensively veined by quartz. In this feature they stand often in strong contrast to the associated greenstones which are usually free from such anastomosing quartz veins.

Under the microscope, the relation these rocks bear to the greenstones is clearly indicated by their banded character, the cordierite areas containing the characteristic streams of ilmenite with granules of apatite as in the less fundamentally altered types. The cordierite-rich lenses and bands alternate with other bands rich in red-brown biotite or into more quartzose and acid plagioclase (albite-oligoclase) bands carrying ilmenite. Many of them contain fine-grained magnetite in considerable amount, which clearly has been introduced.

These rock types appear bound to the anthophyllite-biotite-rich hornfelses by types in which anthophyllite is present in variable amount among the biotite-rich layers. Two of these hornfelses from Zawn a Bal have been analysed (table I, analyses nos. 7 and 8). One of these (no. 7) is a dark-red fine-grained rock, which on the weathered surface shows white streaks and knots as excrescences. On the fractured surface the presence of cordierite is indicated in the resinous-lustred elliptical areas up to $\frac{1}{2}$ inch in length. Under the microscope, the minerals seen are cordierite of the resinous patches referred to containing streams of ilmenite, biotite, and granules of apatite. In these ilmenite streams there is a considerable amount of rutile which

has arisen from the ilmenite by loss of iron. Between the cordierite areas are developed biotite-rich zones which in places also carry ilmenite streams, also quartz, and a fair amount of oligoclase-albite (fig. 4*b*). The white streaks consist largely of quartz accompanied by tufts of white mica. It is clear that much of the quartz in this rock has been introduced, as is evident from its predominance in the streaked patches.

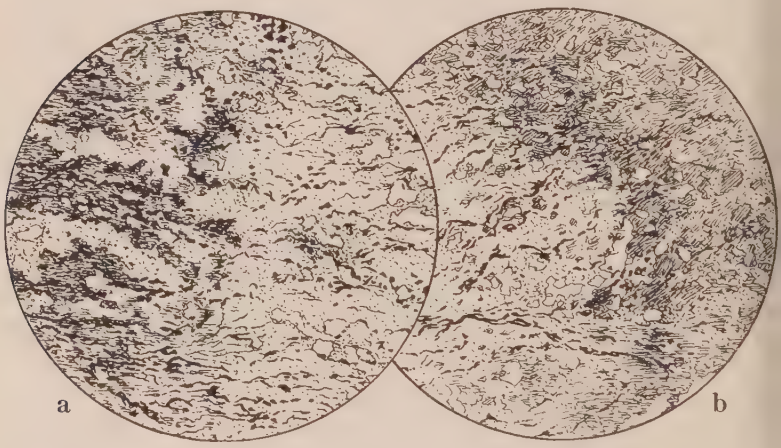

Fig. 4*a*. Cordierite-biotite-hornfels, Zawn a Bal. The right half of the figure consists of a large twinned crystal of cordierite enclosing ilmenite, magnetite, and quartz. The left half contains abundant biotite. The streams of ilmenite persist.

Fig. 4*b*. Cordierite-biotite-hornfels, Zawn a Bal. Streams of ilmenite traversing a cordierite crystal enclosing quartz and oligoclase-albite (left half of figure), right half rich in biotite.

The second rock (Z B 22) is dark-grey in hand-specimens with a knotted weathering (cordierite). Under the microscope, it is seen to be a banded type which has been clearly enriched in quartz and iron-ores (fig. 4*a*). The cordierite areas have the familiar ilmenite streams, but in addition have numerous idioblasts of magnetite. The biotite areas contain, in contrast to the previous rock, a yellow-brown biotite associated with finely granular quartz and albite-oligoclase. This rock also contains knots of quartz and acid plagioclase.

The amount of cordierite in rocks grouped under this heading is subject to considerable variation and appears dependent on the amount of silicification and introduction of potash. There are some

types in which cordierite is in very small amount, its place being taken by quartz or by biotite. The significance of the replacement processes in relation to the development of these extreme variants will be referred to hereafter.

Occurrence of almandine at Botallack.

The well-crystallized icositetrahedra of garnet recorded from Botallack and often to be seen in British mineral collections have recently been analysed.[1] The garnets were originally found only in one place—at low-water mark on the promontory north of Zawn a Bal amongst the altered greenstones. The analysis of this garnet shows it to be an almandine-rich variety of composition $Fe_{91\cdot3}Mn_{1\cdot7}Mg_{2\cdot4}Ca_{4\cdot6}$. The crystals rest upon a highly biotitic layer of the altered rocks, and an analysis (table I, no. 9) has been made of the country-rock to which the garnets belong. The almandine contains enclosures of red-brown biotite and grunerite. The surrounding rock is banded, containing, immediately adjacent to the garnet, layers rich in biotite and quartz. Passing out from the contact with the garnets the biotite passes from a yellow-brown to a green-brown variety, the associated mineral being quartz. This band is succeeded by another composed almost wholly of grunerite with some green biotite and quartz (fig. 5).

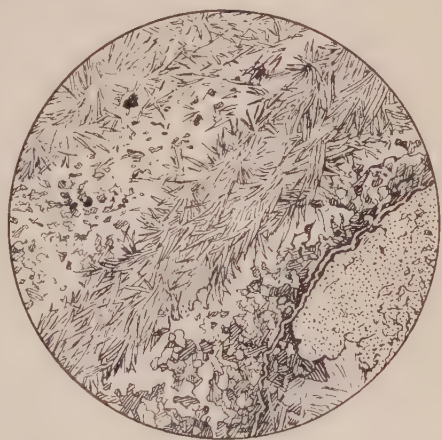

Fig. 5. Grunerite-biotite-quartz-hornfels, Zawn a Bal. Almandine bordered by a felt of biotite, the remainder of the figure grunerite in bands with quartz and biotite.

In hand-specimens the grunerite is greenish-brown, but in thin section almost colourless: α and β colourless, γ light greenish-yellow. It is commonly multiple twinned on (100), $\gamma : c = 12°$, optic axial angle high, negative, γ 1·715. It is clear from these properties that the monoclinic amphibole must be close to grunerite in composition.

[1] A. R. Alderman, Min. Mag., 1935, vol. 24, p. 42.

The garnet-free material analysed comprises the two layers, biotite-quartz and grunerite-biotite-quartz, and the high percentage of ferrous oxide (26·75 %) and low magnesia (2·37 %) confirm the gruneritic character of the amphibole.

In all specimens examined garnet occurs in intimate association with biotite but it may also be found adjacent to grunerite bands. There can be no doubt that this occurrence of garnet is connected with the strong metasomatism that has affected the country-rock. The original material has been a metamorphosed greenstone which has suffered intense impregnation with potash, iron oxide, and silica. Among the garnetiferous specimens in the mineral collection at Cambridge there are other types from this locality where the garnet is embedded in a groundmass composed almost wholly of biotite, frequently chloritized, or where the garnet occurs in a biotite-rich zone of a biotite-cordierite-plagioclase-spinel aggregate.

In a previous paper[1] I have referred to the rarity of almandine in normal contact metamorphism, the common red garnet in lime-poor rocks under these conditions being characteristically a spessartine-bearing variety. But at Botallack manganous oxide is but sparingly present. While this occurrence does not affect the conclusion that manganiferous garnets are to be expected in the normal contact alteration in a lime-poor environment, it does make clear that almandine can arise in thermal aureoles without the adjunct of stress or high hydrostatic pressure. No appeal to these agents can be made for the Land's End aureole. In the paper referred to (p. 50) it was stated: 'It is as yet impossible to estimate what contributory part, if any, the presence of abundant water during metamorphism—as the principal garnet-bearing aureoles reveal—plays in producing a concentration of an orthosilicate molecule as garnet.' In this connexion it may be added that the Land's End aureole is of the wet and probably low-temperature type alluded to, as is evident from the mineral paragenesis both in the sediments and the metasomatic greenstones, and in particular from the absence of potash-felspar which is so characteristic a feature of dry aureoles like Oslo and Comrie.

Origin of the hornfelses.

A summary of the principal types of hornfelses which are derivatives of the greenstones is given below.

[1] C. E. Tilley, Min. Mag., 1926, vol. 21, p. 47.

Hornblende-plagioclase-rocks (typical greenstone-hornfelses)
Hornblende-biotite-plagioclase-rocks
Cummingtonite-plagioclase ± biotite-rocks
Cummingtonite-anthophyllite-plagioclase-cordierite ± biotite
Anthophyllite-cordierite-biotite ± plagioclase
Biotite-cordierite-plagioclase-quartz ± anthophyllite

} with spinel-diaspore-bearing varieties.

The evidence of field and microscopic study leading to the conclusion that all these rock types have a genetic relationship having already been given, it remains to consider again the manner in which the fundamental changes in chemical and mineralogical composition have been brought about.

The conception that the chemical changes were brought about under the influence of intensive weathering of the greenstones followed by further changes during shearing movements is a tempting one, and was that adopted in the Kenidjack paper. After a renewed study, the writer has concluded that appeal must be made to agencies other than those of chemical weathering. The processes of weathering in action at the present day, and affecting basic igneous rocks of the composition of the Cornish greenstones, so far as they have been studied, have not yielded residuals with a closely similar chemical composition. One of the chief characteristic features of the analyses of weathered basaltic rocks is the low content of magnesia they show.

Lime, magnesia, and soda are indeed the most soluble constituents and decrease gradually and regularly with increasing residual character. This is brought out very clearly in the data set out by Merrill[1] and confirmed by more recent studies. The Kenidjack rocks show the pronounced loss in lime expected, but it is in their content of magnesia that they stand in direct contrast to weathering residuals of basic igneous rocks.

Analyses like those of the cummingtonite- and anthophyllite-rocks are not matched among available residual weathering products.[2]

[1] G. P. Merrill, Rocks, rock weathering and soils. 1906.

[2] The analysis of the weathered product of the Rowley Regis dolerite given by H. Warth (Geol. Mag., 1905, p. 21) is in some ways exceptional. The analyses of the fresh rock (I) and the weathered top (II) are given as follows:

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MgO.	CaO.	Na_2O.	K_2O.	H_2O.	P_2O_5.
I.	49·3	0·4	17·4	2·7	8·3	4.7	8·7	4·0	1·8	2·9	0·2
II.	47·0	1·8	18·5	14·6	—	5·2	1·5	0·3	2·5	7·2	0·7

Here the chief contrast between the fresh and weathered basalt is the loss of CaO and Na_2O, enrichment in K_2O, and gain in water. MgO has suffered little change. The unusual character of this analysis merits further investigation of the weathering products of the Rowley Regis dolerite.

The important chemical changes normally effected by the weathering of basaltic rocks are graphically compared with those that have operated on the basaltic greenstones of Kenidjack in fig. 6.

The view already expressed at the beginning of this paper that the chemical changes took place under the influence of solutions emanating from the granite can now be considered in more detail.

In the vicinity of Zawn a Bal, particularly on the promontory between this Zawn and De Narrow Zawn, all the rock types referred to in the foregoing account are well displayed. The metamorphosed greenstones are seen to pass by gradation into the rock types described. This gradual passage takes place not only across but laterally along the prominent banding. Hornblende-plagioclase-rocks pass thus into cummingtonite-plagioclase-biotite assemblages and into cordierite-rich types with or without anthophyllite. In various localities these transitions are especially marked in the vicinity of small zawns and fractures which have served as channels for solutions. The larger zawns mark the sites of tin or copper lodes, the vein material of which has been selectively removed by weathering agencies yielding narrow steep clefts in the cliff face.

It is considered, therefore, that hot solutions eventually emanating from a granite source have passed through the greenstones and produced an effective removal of lime with the production of anthophyllite and related types of hornfelses. The process is in reality one of contact metasomatism. It is believed that while the chief substance removed has been lime, the process has not been one of simple abstraction, but of replacement in which the constituents removed have been replaced by other material. As already noted, there has been a clear introduction of potash resulting in the formation of much biotite in some of these rocks. In comparing the analyses of the various rocks believed to be related to one another we cannot, however, use the basis of comparison instituted by Merrill, i.e. assume some constituent to remain constant. For this assumption there is no justification. A more reasonable assumption is that the chemical changes have operated without volume change. The preservation of the essential textural features of the greenstones and the absence of drusy structures is in harmony with this assumption. The analyses have therefore been recalculated in terms of equal volumes.

In table III are given in the columns numbered 3–9, the gains and losses in grams per 100 c.c. of rock, the basis of comparison being

ne average of the two greenstone analyses 1 and 2. The mineralogy f the greenstones has been shown to be simple but with considerable ariation in the proportions of hornblende and plagioclase. Of the wo analyses, one represented a rock rich in hornblende, while the

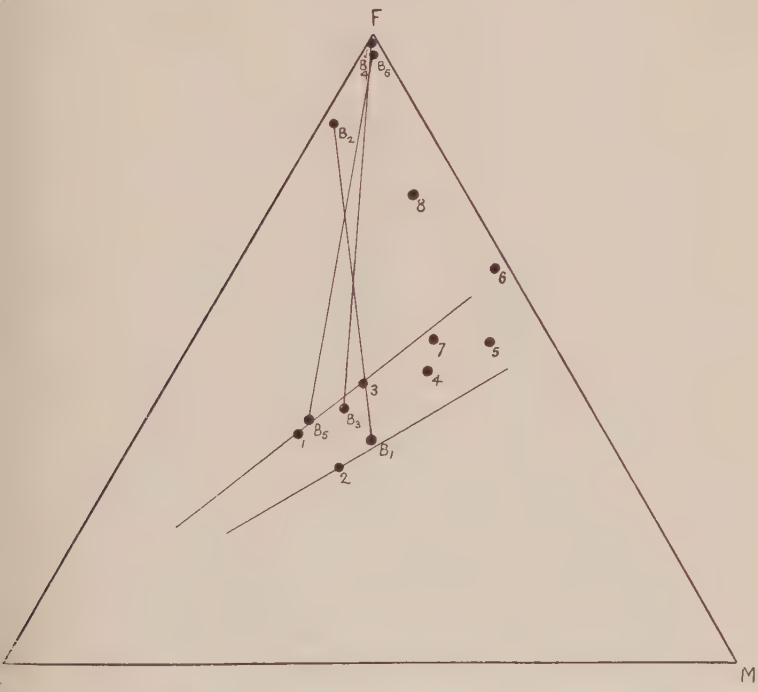

FIG. 6. Plot of analyses of the greenstones and anthophyllite-rocks of Kenidack and Botallack, compared with analyses of basalts and their weathered roducts.

1–8 ... Analyses 1–8 of table I.
B_1—B_2 ... Basalt and its weathered product, Oberkassel (Zeits. Deutsch. Geol. Gesell., 1904, vol. 56, p. 1819).
B_3–B_4 } ... Basalt lavas and their weathered products (Amer. Journ. Sci.,
B_5—B_6 } 1929, ser. 5, vol. 17, p. 314).
C = [CaO]; F = [FeO+Fe_2O_3]; M = [MgO].

econd was a banded type with 30% plagioclase. The average f these two analyses is chosen for comparative purposes. It is of ourse not possible to be confident that the actual analysed rocks hich are compared come from a rock of identical composition;

TABLE III. Gains and losses of constituents per 100 c.c. of rock, analyses 3–9 compared with the mean of analyses 1 and 2 (table I).

	3.	4.	5.	6.	7.	8.	9.
SiO_2	+34·2	+ 5·7	− 2·4	−37·2	+ 9·0	+ 9·9	+22·4
TiO_2	− 0·5	+ 2·1	+ 0·2	+ 3·0	− 0·8	+ 0·4	− 4·8
Al_2O_3 ...	− 4·6	+ 6·3	+15·4	− 7·4	+14·9	+ 4·6	−17·9
Fe_2O_3 ...	− 4·3	− 3·9	− 4·3	+30·0	− 3·7	+ 8·6	− 2·0
FeO	− 1·3	+ 4·7	+ 3·6	+19·8	−11·8	+ 1·3	+47·3
MgO	− 9·6	− 0·4	+ 0·5	+18·5	−14·7	−17·4	−21·7
CaO	−23·9	−28·8	−38·7	−42·2	−38·0	−40·5	−41·3
Na_2O ...	− 0·7	+ 1·0	+ 0·5	− 1·9	+ 2·4	+ 6·6	− 3·0
K_2O	− 1·3	− 0·9	+ 4·0	− 0·7	+11·6	+ 6·6	+ 7·2
&c.	− 1·0	− 1·5	+ 0·7	+10·0	+ 1·2	− 0·5	+ 3·3
Totals ...	−13·0	−15·7	−20·5	− 8·1	−29·9	−20·4	−10·5

nevertheless the range of chemical composition of the original greenstones is not so great that some valid comparisons cannot be drawn. When the figures tabulated in table III are inspected, the features that can be considered significant are as follows:

1. Lime is the chief oxide that has been removed, falling from 14 % in the greenstones successively to under 1 % in the anthophyllite-cordierite-spinel-diaspore-hornfels.

2. Silica has clearly been added in some examples, in 3, 7, 8, and 9. This addition of silica is supported also by the microscopic characters of the rocks indicated. In the cummingtonite-plagioclase-hornfels (table I, analysis 3, table III, no. 3) quartz is present among the plagioclase bands (Ab_1An_1) and also forms in narrow venules. The cordierite-biotite-hornfelses (nos. 7 and 8) contain clear quartz in nests amongst the biotite and cordierite areas, which form excrescences on the weathered surface. It has already been remarked that this variety of hornfels in the field is frequently crossed by numerous veins of introduced quartz, whereas the surrounding greenstones are usually free from these veins. The grunerite-biotite-quartz-hornfels has clearly also suffered an introduction of silica, and plagioclase is scarcely represented in its constitution. On the other hand, one rock—the cordierite-anthophyllite-spinel-diaspore-rock—is a basic type which has lost silica.

3. Iron oxides. The most striking example of accession of iron oxide is the grunerite hornfels (no. 9) containing 26·75 % FeO. It is this rock which is the home of the analysed almandine garnet. Accession of iron oxide is also unmistakable in no. 6, revealed in abundant spinel and magnetite, and in the cordierite-biotite-hornfels

no. 8), which contains abnormal amounts of ferric oxide in the form of magnetite.

4. Magnesia. The only rock where addition of magnesia can be confidently postulated is the anthophyllite-cordierite-spinel-diaspore-hornfels with a content of 15·55 % MgO. This rock appears to have suffered loss of lime and silica and received notable gains in iron oxides and magnesia. The biotite-cordierite-hornfels and the grunerite-biotite-hornfels, on the other hand, have lost magnesia.

5. Alkalis. The biotite-rich hornfelses (nos. 7, 8, and 9) reveal a clear addition of potash and no. 8 an addition of soda. This deduction is supported by their richness in biotite and the presence of considerable albite-oligoclase in no. 8 associated with quartz forming nests of introduced material. Of the other oxides, alumina must be considered removed in the grunerite-hornfels (Al_2O_3 8·40 %) and has possibly been added in nos. 5 and 7. The small changes in the alumina of the remaining rocks cannot be considered significant.

The examination of tables I and III makes it evident that the metasomatism effected has been a consistent removal of lime partly compensated by additions of silica, iron oxides, and alkalis, more particularly potash, but that these gains are not revealed throughout the series (fig. 7). Replacement has resulted in the development of rock types of less density.

Among the common end-products of metasomatism of the greenstones is a biotite-cordierite-hornfels, which mineralogically is closely similar to the mineral assemblage of contact altered normal shales. Like the anthophyllite-cordierite-rocks, however, the biotite-cordierite-hornfelses show certain chemical peculiarities, viz. richness in iron oxides and magnesia, inherited from their parent rock. The chemical characters of these rocks compared to those of normal shales, slates, and mica-schists is indicated in fig. 8. Mineralogically, the metasomatism is expressed in replacement of green hornblende areas by cummingtonite and anthophyllite, and the plagioclase gives place eventually to cordierite. It is clear, however, that we cannot explain the process by any simple equation which represents it as an exchange of ferrous oxide and magnesia for lime.

The removal of lime from green hornblende leaves Mg, Fe, Si, and Al in excess of that required for cummingtonite, or alternatively an excess of Si and Al. The incoming of the magnesia-iron-amphiboles and the disappearance of green hornblende probably involves a complex change in which the removal of lime from the rock is accompanied

by internal migration of magnesia and iron oxide as well as alumina. The green hornblende of these greenstones, as has been shown, must have contained in many cases high percentages of alumina which is unrepresented in the new cummingtonite formed. The cummingtonite analysed (table I, no. 10) contains only 2·78% Al_2O_3. Among

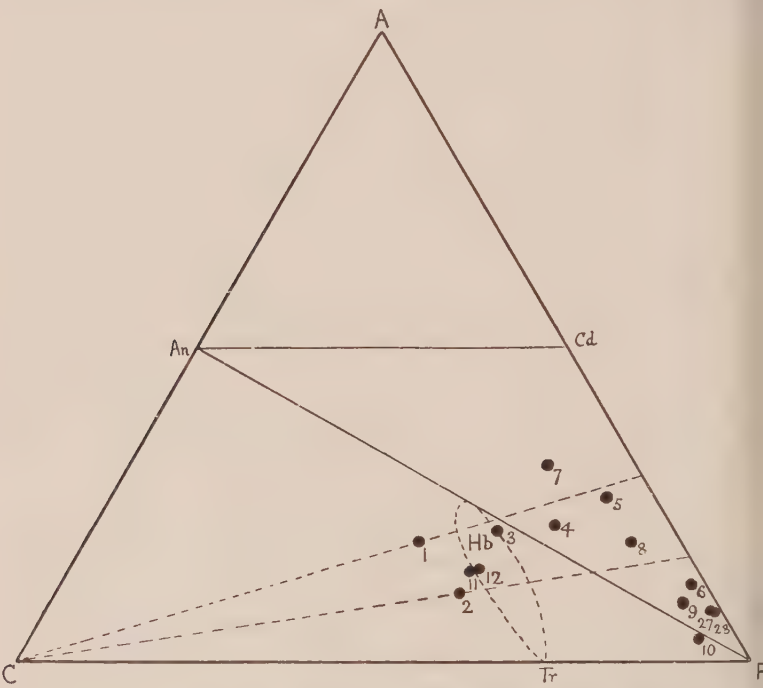

Fig. 7. Plot of analyses of greenstones, anthophyllite- and cummingtonite rocks of Kenidjack and Botallack.

1–10 ... Analyses 1–10 of table I.
11 ... Average plateau basalt (Proc. Amer. Acad. Arts and Sci., 1925 vol. 60, p. 73).
12 ... Hornblende-schist, Meneage, Cornwall (Geol. Lizard an Meneage, Mem. Geol. Surv., 1912, p. 48).
27–28 ... Anthophyllite analyses, Orijärvi region (Bull. Comm. Géo Finlande, 1915, no. 44, p. 59).

A = $[Al_2O_3-(K_2O+Na_2O)]$; C = [CaO]; F = [FeO+MgO].
An = anorthite; Cd = cordierite; Hb = field of hornblendes; Tr. = tremolite

analysed members of the cummingtonite-grunerite series there seem to be no representatives rich in sesquioxides, such as are found among the anthophyllite-gedrite series.

The formation of cordierite in place of plagioclase, appearing only when all green hornblende has disappeared, is to be regarded as a replacement of lime by magnesia and ferrous oxide derived in part from the hornblende→cummingtonite (anthophyllite) conversion. Such internal migration is made evident by residual plagioclase

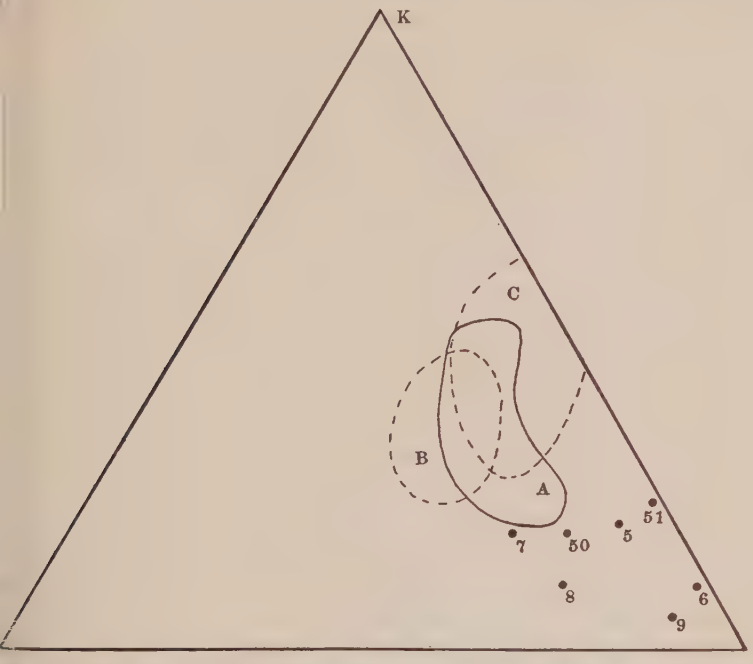

FIG. 8. Plot of analyses of the anthophyllite-cordierite-rocks, &c., of Kenidjack and Botallack in relation to the concentration fields of slates (A), mica-schists (B), and chloritoid-schists (C).

5–9 ... Analyses 5–9 of table I.

50–51 ... Analyses of similar rocks from the Orijärvi region (Bull. Comm. Géol. Finlande, 1915, no. 44, pp. 65–66).

$O = [K_2O + Na_2O]$; $K = [Al_2O_3 - (K_2O + Na_2O + CaO)]$; $S = [FeO + MgO]$.

in the cordierite areas which still retain the ilmenite streams of the original greenstones, and the formation of narrow veins of cummingtonite traversing the hornfelses.

Introduction of potash from without is responsible for biotite which characterizes many of these hornfelses, sometimes in abundance. The mica takes the place of cordierite or eventually of the amphiboles. Pseudomorphs of biotite after cummingtonite can be recog-

nized, and the replacement of plagioclase areas by felts of biotite containing plagioclase residuals make clear the metasomatic exchange which has operated in these hornfelses.

In the development of spinel and diaspore together with clinochlore in some of the early stages of alteration of the greenstones the same process is effective.

Comparison with rocks of other areas.

Among published data probably no closer comparison could be made of the Kenidjack rocks than with those of the Amulet mines, Quebec, and the cordierite-gedritites of the Bamle formation, southern Norway.

1. Amulet mines, Dufresnoy township, Quebec.[1]—The chief rocks of the Amulet mines are Keewatin rhyolites and dacites. Particularly along the boundaries of these two lava groups sulphide ore-bodies (pyrite, pyrrhotine, chalcopyrite, and zinc-blende) have been introduced and these are surrounded by areas of mineralization within the lavas. The dacites in the mineralized zones suffer fundamental changes in composition with the production of cordierite-bearing types including the rock styled *dalmatianite*. The authors of the Survey Memoir (1931) in describing these alterations state that dacite, constituted of biotite 3–4, quartz 2–3, green hornblende 40, and oligoclase 50–55 %, is first converted to a rock made up of biotite 40, quartz 15, recrystallized actinolite 5–10, and oligoclase 35–40 %. In a later stage of alteration they are converted to a spotted rock made up of quartz, chlorite, ' colorless hornblende ' with a very small extinction-angle, the spots consisting of sericitic aggregates including within themselves numerous quartz grains. The sericitic aggregates are tentatively referred to altered cordierite. A final stage is recorded from the mine in which the matrix is wholly chlorite with some ' hornblende ', and the spots are recognized as cordierite. Some of these altered rocks have been studied and analysed by Dr. T. L. Walker, who has given a description of the chief types. Dr. Walker has kindly forwarded to the writer specimens of the rocks analysed together with a specimen of typical dalmatianite. This is a white spotted rock with large spots of cordierite showing sieve

[1] H. C. Cooke, Summ. Report Geol. Surv. Canada, 1925, part C, p. 41; T. L. Walker, Univ. of Toronto Studies, Geol. Series, 1930, no. 29, p. 9 [M.A. 4–401]; H. C. Cooke, W. F. James, and J. B. Mawdsley, Mem. Geol. Surv. Canada, 1931, no. 166, pp. 206–218.

xture with numerous quartz and biotite enclosures and occasionally mall grains of green spinel set in the cordierite. The matrix between ne spots is composed principally of biotite with some quartz.

The three analysed rocks are rich in cordierite. One is a cordierite-iotite-quartz-hornfels with a fair proportion of oligoclase; the second an anthophyllite-(with cummingtonite)-cordierite-quartz-biotite-ornfels; while the third, a more basic type, has a groundmass rich n chlorite with brown biotite and contains clear spots of twinned ordierite with sheafed aggregates of anthophyllite. Numerous cattered idioblasts of green spinel occur both in the matrix and in the erdierite. The rock types produced at the Amulet mines are clearly om these descriptions closely allied to the rocks of Kenidjack. The eld data in the Survey reports—the close association of the spotted nd altered rocks with the ore-bodies—make it abundantly clear that hey owe their development from the dacites (and rhyolites) to the assage of solutions associated with the copper ore-bodies. At Kenidjack the parent rocks and the metasomatic products were ypically more basic.

2. Kragerø region.—In a recent memoir Brögger[1] has described in he Kragerø district of southern Norway, cordierite-gedritites which ppear everywhere to be connected with amphibolites or amphiboli-ic schists. The gedrite-bearing rocks also include gedrite-plagioclase ypes (Skåtø type) of the Bamle formation, and these are linked by ransitional varieties with the cordierite-bearing members. They re interpreted by Brögger 'as a special facies of the amphibolites or erhaps as rocks originated by the metamorphosis of amphibolites eventually by the carrying away of certain amounts of CaO and ikalis)'. These rocks in their association with basic igneous rocks learly have a similar chemical environment to those of Kenidjack, ut beyond the conclusion already stated above Brögger gives no detailed discussion of their precise mode of origin.

During the last twenty-five years, anthophyllite-cordierite-rocks, ather similar to the Kenidjack type, have been recognized in numerous ocalities of Sweden and Finland (Grängesberg, Falun, Riddarhyttan, Orijärvi, &c.), more particularly by the work of Johansson, Eskola, and Geijer.[2]

[1] W. C. Brögger, Vid.-Selsk. Skrifter, I. Math. Naturv. Kl. 1934, no. 1, p. 225.

[2] H. E. Johansson, Geol. För. Förh., 1910, vol. 32, p. 239; P. Eskola, Bull. Comm. Géol. Finlande, 1914, no 40; P. Geijer, Årsbok Sveriges Geol. Unders., 916, vol. 10, no. 1, and Kungl. Kommerskoll. beskriv. mineralfyndig., 1923, no. 1.

The studies of Eskola and Geijer have led these authors to conclude that anthophyllite-cordierite-rocks in the Fennoscandian pre-Cambrian have arisen by metasomatic processes affecting more particularly siliceous leptites. The introduced materials include particularly magnesia and iron oxides, and the process has often been referred to under the term magnesia-metasomatism. The writer must confess that he originally felt somewhat sceptical of the reality of the magnesia-metasomatism suggested by Eskola and Geijer for the genesis of these rocks, more particularly as at Orijärvi there were abundant basic intrusions—amphibolites—often associated with them. He therefore takes this opportunity of adding that he has recently had the privilege of visiting the Orijärvi area under the guidance of Professor Eskola and has been convinced that many of the anthophyllite-cordierite-rocks show a metasomatic relation to siliceous leptites. The gradual transitions that can be followed at Orijärvi between the leptites and the cordierite-anthophyllite-rocks, and the intimate association of the 'ore quartzites' with the sulphide ore-bodies, make clear the operation of metasomatic solutions carrying in magnesia and iron oxides.

The Kenidjack rocks can thus be brought into line with the similar rocks of Sweden and Finland with this important difference, that in the former case the parent rocks were essentially basic and the metasomatic processes involved a widespread removal of lime, accession of silica, alkalis, particularly potash, and an *internal* magnesia-metasomatism as contrasted with an accession of magnesia characterizing the Orijärvi and Falun regions.

Explanation of Plates VI and VII.

Greenstone-hornfelses of Kenidjack and Botallack, Cornwall.

Plate VI, Fig. 1. Zawn a Bal promontory. Greenstones below passing upwards through cummingtonite-biotite-hornfelses into cordierite-anthophyllite-rocks (ball rock).

— Fig. 2. North face of Zawn a Bal, Botallack, showing greenstones on the left below with anthophyllite-cordierite-rocks (veined) above. Below on the right bands of cummingtonite-hornfelses.

Plate VII, Fig. 3. Zawn a Bal. Striped greenstones passing to cummingtonite-biotite-plagioclase-hornfelses and cordierite-bearing types.

— Fig. 4. Pillow lavas, south-west side of Kenidjack cliff.

Fig. 1

Fig. 2.

C. E. TILLEY: GREENSTONE-HORNFELSES, CORNWALL

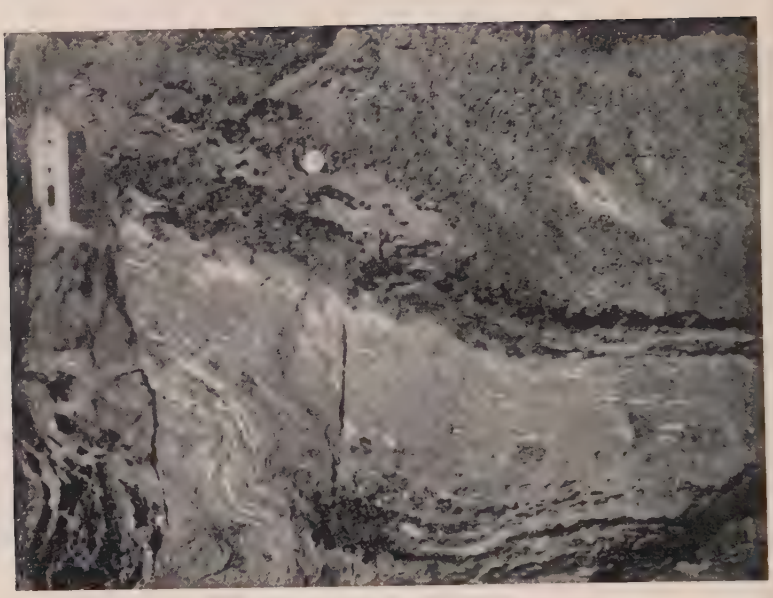

Fig. 3.

Fig. 4.

C. E. TILLEY: GREENSTONE-HORNFELSES, CORNWALL

The influence of chemical factors on the crystallization of hornblende in igneous rocks.

By W. Q. Kennedy, D.Sc.
H.M. Geological Survey of Great Britain.

[Read March 15, 1934.]

IT is now more than sixty years since Tschermak first published his classical paper on the relationship between the pyroxenes and amphiboles,[1] but, in spite of our greatly increased knowledge of these important rock-forming minerals, many of the problems concerning their constitution and genesis remain unsolved. In particular, the nature of the conditions which determine whether a pyroxene or an amphibole will separate from a crystallizing magma are imperfectly understood, although the point is one of very considerable petrological significance. Much fuller information is necessary, particularly with regard to the relationship between the composition of the ferromagnesian minerals and the rocks in which they occur. The present paper merely represents a preliminary attempt to correlate the available chemical evidence and to determine what other possible factors might influence the character of the ferromagnesian crystallization.

It is very generally supposed that the concentration of the volatile components (water, &c.) in the magma determines whether hornblende or augite will crystallize out. This conception is based on several factors.

(*a*) The pyroxenes and hornblendes are metasilicates of magnesium, calcium, and iron, and, taken as a whole, the two groups are superficially rather similar both as regards chemical composition and crystallographic characters. For this reason they were considered to be dimorphous.

(*b*) The pyroxenes are of simple constitution and are anhydrous, whereas the hornblendes are chemically more complex and contain essential water, fluorine, &c.

[1] G. Tschermak, Beziehung zwischen der Pyroxen- und Amphibolgruppe. Min. Mitt., 1871, p. 17.

(*c*) Amphibole does not crystallize from a dry melt in the same manner as pyroxene, but requires the presence of mineralizers.

(*d*) When hornblende is fused and allowed to crystallize it forms pyroxene plus a little magnetite, and does not simply recrystallize as the original amphibole.

(*e*) Amphiboles are characteristic of the deep-seated plutonic rocks which crystallized under pressure sufficient to retain the volatile components, whereas pyroxenes are typical of the rapidly cooled volcanic rocks from which most of the volatiles escaped during crystallization.

Actually, however, as pointed out by Eitel[1] and Kunitz,[2] the chemical similarity between the two groups is not nearly so close as Tschermak and his followers believed, but the resemblance is confined to the actinolite and cummingtonite series of the amphiboles. Some factor other than pressure and the concentration of the volatile components must control the separation of the minerals.

A similar view has been expressed by Niggli[3] and by Bowen[4] and is summed up by the former author in the following words: 'Es geht daraus mit Deutlichkeit hervor, dass die Frage, weshalb in einem Magma sich Augite statt Hornblenden bilden, oft nicht nur eine Antwort vom physikalischen Standpunkte erheischt, sondern auch vom chemischen.'

The most suitable method of attacking the problem seems to be by a statistical comparison of the chemical compositions of the two groups, and, as shown below, this method leads to the conclusion that the ratios of the basic oxides in the magma are of primary importance in determining whether pyroxene or hornblende will separate from the melt.

The MgO–CaO–FeO ratios of the Pyroxenes.

Within recent years Asklund[5] has published an elaborated survey of the crystallization courses of the pyroxenes and pyroxene-bearing rocks, based on a very complete statistical study of their MgO–CaO–

[1] W. Eitel, Die Mischkristallbildung in der Gruppe der alkali- und tonerdhaltigen Hornblenden . . . Neues Jahrb. Min., 1922, Beil.-Bd. 47, pp. 214–217.

[2] W. Kunitz, Die Isomorphieverhältnisse in der Hornblendegruppe. Neues Jahrb. Min., Abt. A, 1930, Beil.-Bd. 60, pp. 173–174. [M.A. 4–200.]

[3] P. Niggli, Gesteins und Mineralprovinzen. Berlin, 1923, pp. 77–78.

[4] N. L. Bowen, The evolution of the igneous rocks. Princeton, 1928, p. 91.

[5] B. Asklund, Petrological studies in the neighbourhood of Stavsjö . . . Årsbok Sveriges Geol. Undersök., 1925, vol. 17, no. 6, pp. 75–88.

FeO ratios. This work, which represents a continuation and extension of the investigations of Wahl [1] and Sosman,[2] serves as a basis for the present comparative study, as regards the pyroxenes.

Both Sosman and Asklund were able to show that, among natural pyroxenes, an immiscibility gap exists between the diopside-hedenbergite series and the magnesia-rich, lime-poor monoclinic and ortho-

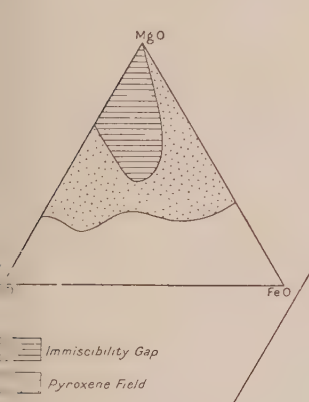

Fig. 1.

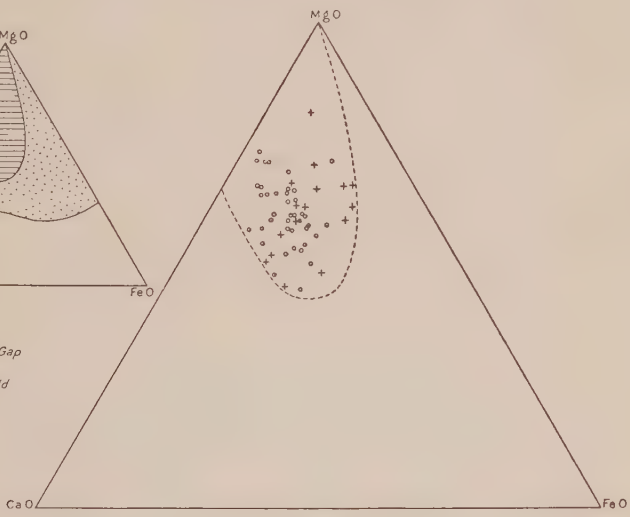

Fig. 2.

Fig. 1. Diagram showing the MgO–CaO–FeO ratios of the pyroxenes and metasilicate proportions of pyroxene-bearing rocks. (After B. Asklund.)

Fig. 2. Diagram showing the MgO–CaO–FeO ratios of igneous hornblendes (○) and metasilicate proportions of rocks containing hornblende as the sole ferromagnesian constituent (+).

hombic pyroxenes. No points expressing the analyses of pyroxenes all within this area and homogeneous pyroxenes of such composition do not exist in nature. This appears to be contrary to the results obtained by Bowen [3] in his study of synthetic pyroxenes, for he found a complete series of mixed crystals in the system diopside-clinoen-

[1] W. Wahl, Die Enstatitaugite. Min. Petr. Mitt. (Tschermak), 1907, vol. 26, p. 1–131.

[2] R. B. Sosman, Minerals and rocks of the composition $MgSiO_3$–$CaSiO_3$–$FeSiO_3$. Journ. Washington Acad. Sci., 1911, vol. I, pp. 54–58.

[3] N. L. Bowen, The ternary system: diopside–forsterite–silica. Amer. Journ. Sci., 1914, ser. 4, vol. 38, pp. 207–264.

statite. It is significant, however, that, according to Wyckoff,[1] X-ray study suggests that diopside and clinoenstatite 'unmix' on cooling and give two patterns.

The relations of the natural pyroxenes, according to Asklund, are shown in the triangular diagram of the system MgO–CaO–FeO in fig. 1.[2] In the diagram, points expressing the compositions of single pyroxenes or rocks containing a single type of pyroxene fall outside the shaded area which represents an immiscibility gap in the system. Within this area no homogeneous mixed crystal has been found. On the other hand, points expressing the composition of a mixture of the two types of pyroxene or the metasilicate proportions of rocks containing two independent pyroxenes all fall within the immiscibility area. Thus, if the composition of a rock is such that it is represented by a point within the shaded area of fig. 1, its modal composition cannot be expressed by the crystallization of a single pyroxene, but only by the separation of two independent pyroxenes.

The MgO–CaO–FeO ratios of magmatic Hornblendes.

In order to effect a direct comparison between the magmatic pyroxenes and hornblendes it is evident that the latter must be subjected to the same method of treatment. This involves certain additional difficulties, however, for, as a rule, the hornblendes of igneous rocks contain greater proportions of sesquioxides than the aluminous pyroxenes and they contain also essential water. These factors would appear to invalidate any conclusions which might be drawn from such a statistical comparison.

In this respect, however, we must consider the role of Al_2O_3 in the constitution of the hornblendes. Warren[3] has shown, as a result of his X-ray study of the amphiboles, that part of the alumina replaces silica in the structure and part replaces the MgO group. When allowance is made for these replacements in recalculating the analyses, it is found that the results differ little from those obtained by

[1] R. W. G. Wyckoff, Amer. Journ. Sci., 1925, ser. 5, vol. 10, p. 383.

[2] His method of calculation was as follows (loc. cit., 1923, pp. 75–78). In rocks containing femic silicates completely dominated by abundant pyroxene, the metasilicate proportions of the modal pyroxene were obtained by allotting CaO for anorthite, &c., and FeO for magnetite, &c. The remaining MgO, CaO, and FeO was then recalculated to 100, and the proportions obtained were plotted in the diagram. The same method was employed in the calculation of the analyses of pyroxenes.

[3] B. E. Warren, Zeits. Krist., 1930, vol. 72, p. 493. [M.A. 4–278.]

Asklund's method, and the latter method of calculation is therefore valid.

The MgO–CaO–FeO ratios of forty analyses of igneous hornblendes,[1] together with the basic metasilicate proportions of sixteen hornblende-bearing rocks free from pyroxene and biotite, are plotted in the triangular diagram in fig. 2. It is seen that, without exception, *all the analyses fall within the area representing the immiscibility gap in Asklund's diagram for the pyroxene system.* The grouping is too regular to be fortuitous and must indicate the existence of some fundamental chemical relationship.

Although our knowledge is, as yet, incomplete the following tentative conclusions may be drawn :

(1) The MgO–CaO–FeO ratios of pyroxenes and magmatic hornblendes show marked and characteristic differences and, chemically, the latter appear to form a connecting link between the diopside-hedenbergite series and the magnesia-rich, lime-poor monoclinic and orthorhombic pyroxenes.

(2) The ratios of the oxides in the original melt constitute a determining factor in the separation of pyroxene or hornblende. Rocks which have a composition represented by points outside the immiscibility area (hornblende field) cannot have hornblende as their sole ferromagnesian mineral.

(3) The influence of the volatile constituents is an unknown quantity, but, in some cases, it is found that changes in the ratios of the basic oxides lead to the precipitation of diopside in magmas saturated with respect to hornblende, although the concentration of the volatile components remains the same.[2] At the same time it is probable that any magma from which hornblende would crystallize under conditions tending towards the retention of the volatile components would, under effusive conditions (and with the escape of the volatiles), give rise to a mixture of two independent pyroxenes instead of a single pyroxene. The presence of water alone cannot therefore control the nature of the ferromagnesian crystallization.

[1] These represent the available analyses of hornblendes from igneous rocks quoted from the following sources :—C. Doelter, Handbuch der Mineralchemie, 1912–14, vol. 2 (I), pp. 586–649; H. Rosenbusch, Elemente der Gesteinslehre, 4th edition, 1923; W. Kunitz, loc. cit., 1930, pp. 171–250.

[2] W. Q. Kennedy and H. H. Read, The differentiated dyke of Newmains, Dumfriesshire . . . Quart. Journ. Geol. Soc. London (in the press).

An X-ray examination of substituted edingtonites.

By W. H. Taylor,
Leverhulme Research Fellow, Crystallographic Laboratory, Cambridge.

[Read November 14, 1935; communicated by Prof. W. L. Bragg, F.R.S.]

I. *Introduction. The Edingtonite Structure.*

THE rare barium zeolite edingtonite has been examined in the course of the systematic investigation of the zeolites now being made at the British Museum,[1] and several substitution derivatives have been prepared. The structure of natural edingtonite has also been completely determined by X-ray methods,[2] and in the present paper an account is given of an attempt to discover the exact positions occupied in the substituted edingtonites by the potassium and thallium ions which replace the barium ions of ordinary edingtonite.

Base-exchange products obtained from some other zeolites have already been examined in detail by X-ray methods. In silver-analcime [3] and silver-natrolite [4] the intensities of X-ray reflections are explained satisfactorily on the assumption that each silver ion occupies the exact position previously occupied by the sodium ion which it replaces. In these crystals a monovalent ion in the natural compound is replaced by another monovalent ion in the substitution product. The peculiar interest of base-exchange in edingtonite arises from the fact that each divalent (barium) ion in the natural compound may be replaced by *two* monovalent ions in the substitution product, and the aim of the work to be described is to show how the extra cation is accommodated without any breakdown of the crystal-structure.

[1] M. H. Hey and F. A. Bannister, Studies on the zeolites. Part VI. Edingtonite. Min. Mag., 1934, vol. 23, p. 483.

[2] W. H. Taylor and R. Jackson, The structure of edingtonite. Zeits. Krist., 1933, vol. 86, p. 53. [M.A. 5–354.]

[3] W. H. Taylor, The structure of analcite ... Zeits. Krist., 1930, vol. 74, p. 1. [M.A. 4–369.]

[4] W. H. Taylor, C. A. Meek, and W. W. Jackson, The structures of the fibrous zeolites. Zeits. Krist., 1933, vol. 84, p. 373. [M.A. 5–354.]

Natural edingtonite is a simple example of an aluminosilicate ramework structure, of which a large number have been examined.[1] t is closely related to the zeolites thomsonite and natrolite (with colecite and mesolite), all being fibrous parallel to the *c*-axis, with ight-angled cleavages in the [*hk*0] zone, and a *c*-axis of length 6·6 Å. The orthorhombic unit cell of dingtonite with *a* 9·6, *b* 9·7, 6·6 Å., is dimensionally pseudo-tetragonal, and the intensities of reflection correspond to etragonal symmetry, the space-roup being D_{2d}^3 (tetragonal) or ^{3} (orthorhombic). The unit ell of fully hydrated material ontains $Ba_2Al_4Si_6O_{20}.8H_2O$, nd the structure is essentially etragonal, the slight *dimensional* departure from tetragonal ymmetry probably being a onsequence of the small difference in the sizes of (SiO_4) and AlO_4) groups.

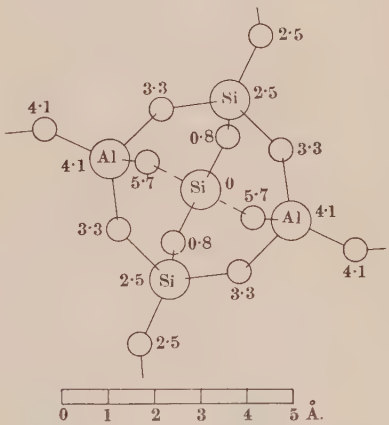

Fig. 1. The tetrahedron chain of edingtonite viewed along its length. Large circles represent silicon or aluminium atoms, small circles represent oxygen atoms. The heights of the atoms are given in Å.

Fig. 1 represents a chain of inked tetrahedral (SiO_4) and AlO_4) groups such as is found n edingtonite, thomsonite, and natrolite. The chain is a rigid tructural unit of length 6·6 Å., and in all these crystals the tetra-edron chains lie side by side with their lengths parallel to the rystallographic *c*-axis. The chains are linked together laterally by haring oxygen atoms and so form a continuous three-dimensional ramework of linked (SiO_4) and (AlO_4) groups. The linkage of the hains is different in the three crystals; in edingtonite every oxygen tom common to two chains lies on a reflection plane as shown in g. 2, which represents the complete atomic arrangement in the unit ell. The relation between the crystal-structure and physical properties of edingtonite has been discussed in detail elsewhere.

The line of intersection of two reflection planes (fig. 2) marks the entre of a channel parallel to the *c*-axis of the crystal and bounded

[1] See, for example, W. H. Taylor, Proc. Roy. Soc. London, Ser. A, 1934, ol. 145, p. 80. [M.A. 6–59.]

by four tetrahedron chains. Water molecules of type Aq_1 form, with oxygen atoms O_A, double columns which bound the 'channels' and include a series of identical cavities with centres at intervals of 3·3 Å.

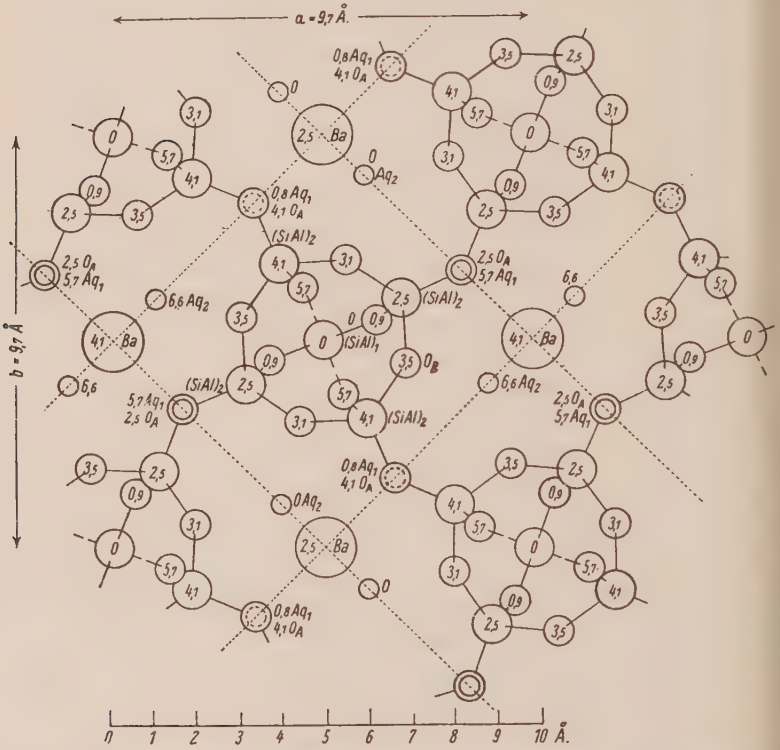

FIG. 2. The unit cell of edingtonite viewed along the *c*-axis. The heights of the atoms above the base of the unit cell are given in Å., and the reflection planes (110) and (1$\bar{1}$0) are indicated by dotted lines. Full lines represent bonds between oxygen and silicon or aluminium.

along the centre line of the channel. At the right-hand side of fig. 2 a barium ion with its centre at height 4·1 Å. above the base of the unit cell occupies one such cavity; cavities at heights 0·8 Å. and 7·4 Å. are unoccupied, only *alternate* cavities at intervals of 6·6 Å. being occupied by barium ions in ordinary edingtonite. The water molecules of type Aq_2 also lie within the channels parallel to the *c*-axis.

Similar channels are found in other zeolite structures, and since

lhe channels are large enough to permit the movement of ions and ater molecules without breaking the strong tetrahedron framework,

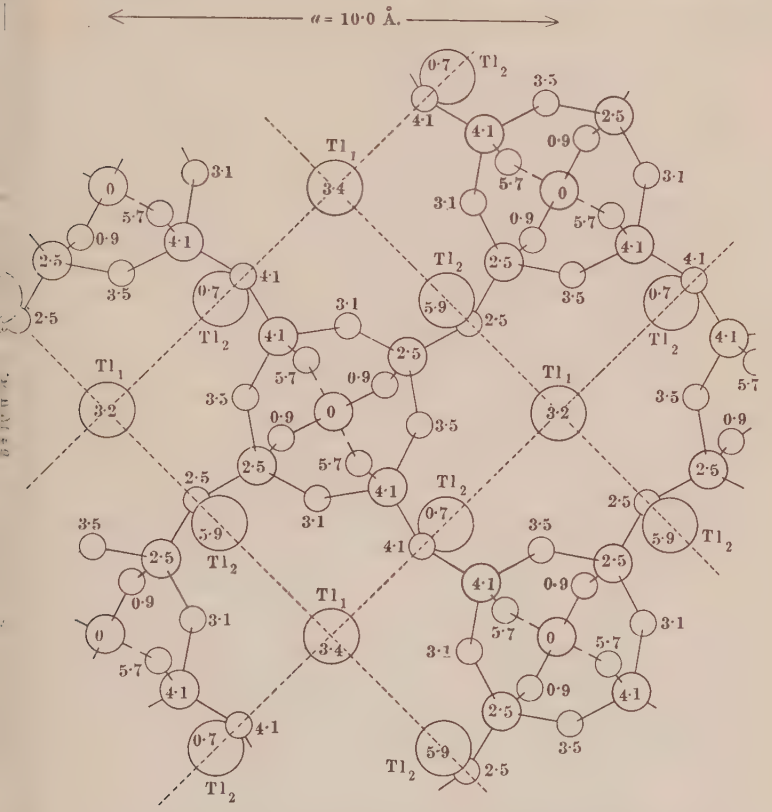

Fig. 3. The unit cell of thallium-edingtonite. This diagram should be compared with fig. 2. In thallium-edingtonite the tetrahedron chains are rotated through a small angle from their positions in ordinary edingtonite, and the atoms Tl_1 are at heights different from those of the Ba atoms which they replace. All atomic positions Tl_2 are shown, although probably only one half of these are occupied.

t is assumed that their existence explains the peculiar dehydration nd base-exchange properties of zeolites.

Of the four substituted edingtonites prepared by M. H. Hey,[1] odium pseudo-edingtonite must differ fundamentally from other dingtonites, since its c axis is not a multiple of 6·6 Å.; silver-dingtonite gives extremely weak X-ray photographs, and therefore

[1] M. H. Hey and F. A. Bannister, loc. cit.

insufficient data for a detailed investigation; the potassium and thallium derivatives give good photographs and have been used for the present work.

II. *Thallium-edingtonite.*

The unit cell of thallium-edingtonite has been measured by F. A. Bannister,[1] and the chemical composition determined by M. H. Hey.[1] The cell, with axes a 9·94, b 10·00, c 6·65 Å., is slightly larger than that of barium-edingtonite and contains 5·82 Si, 3·92 Al, 0·32 Ba, 4·37 Tl, 20 O, 4·87 H_2O, i.e. in whole numbers $Tl_4Al_4Si_6O_{20}$ and water. The intensities of the reflections show tetragonal symmetry and no reflections occur which are forbidden by the space-group D_{2d}^3 of barium-edingtonite; this is therefore assumed to be the space-group of the thallium derivative.

The scattering power of the water molecules is very small by comparison with that of thallium, and they may be left out of account until the main features of the structure are known. The whole investigation is based on the assumption that there is no essential change in the tetrahedron framework during base-exchange, though a small rotation of the tetrahedron-chains is indicated by the longer a- and b-axes.[2] It remains, therefore, to find the positions of the thallium ions; the following possible arrangements have been tested.

(i) The simplest assumption is that thallium ions occupy the cavities previously occupied by barium ions and also the similar cavities (midway between occupied cavities) which are empty in barium-edingtonite (see Section I and fig. 2).[3] In this case the four thallium atoms per unit cell comprise two groups of two equivalent atoms each, with typical co-ordinates $\theta_1 = 180°$, $\theta_2 = 0°$, $\theta_3 = 225°$, and $\theta_1 = 180°$, $\theta_2 = 0°$, $\theta_3 = 45°$, respectively (cf. the atomic co-ordinates quoted in table II). Table I contains a comparison of observed intensities for reflections of low indices and F-values calculated for an arrangement of water molecules and tetrahedron framework identical with that in barium-edingtonite, with thallium ions in the above positions. The complete lack of agreement indicates that the real structure must be quite different from that assumed in calculating the above F-values. On account of the great scattering power of the thallium ions, omission of the water molecules or rotation of the tetrahedron chains could make no appreciable difference in this comparison.

[1] M. H. Hey and F. A. Bannister, loc. cit.

[2] See also W. H. Taylor, 1934, loc. cit., p. 83.

[3] See also ibid., p. 94.

TABLE I. Thallium-edingtonite. Comparison of observed intensities of reflection and calculated F-values.

$\sin\theta$.	hkl.	F(calculated).	I(observed).	$\sin\theta$.	hkl.	F(calculated).	I(observed).
0·051	110	225	1–2	0·066	101	15	nil
0·072	200	305	2–3	0·075	111	50	5–6
0·081	120	40	nil	0·098	121	35	nil
0·103	220	270	10	0·115	102	250	nil
				0·116	221	90	4
				0·120	112	80	8
				0·136	122	280	nil

In the above table θ is the glancing angle corresponding to Mo$-$K$_\alpha$ radiation with wave-length 0·71 Å., the observed intensities are arranged on an arbitrary scale in which 1 is very weak and 10 very strong, and the F-values are calculated for the following structure (Case (i), Section II of the text):—

Water molecules and tetrahedron framework as in ordinary edingtonite.
$2Tl_1$ with co-ordinates $\theta_1 = 180°$, $\theta_2 = 0°$, $\theta_3 = 225°$.
$2Tl_2$,, ,, $\theta_1 = 180°$, $\theta_2 = 0°$, $\theta_2 = 45°$.

(ii) If no departure from the symmetry of D_{2d}^3 is permitted the only alternative arrangement of the thallium atoms is that they form one group of *four* equivalent atoms lying on the reflection planes. On comparing observed intensities of reflections ($hk0$) with F-values calculated for all possible parameters of the thallium atoms, we have failed to find any agreement.

(iii) The individual unit cell cannot therefore conform to the symmetry of D_{2d}^3, which is the symmetry of the macroscopic crystal. We have therefore used the 'average' method which was applied successfully to analcime (loc. cit., 1930). In that crystal sixteen sodium ions were assumed to occupy uniformly on the average twenty-four equivalent positions of the cubic space-group; the physical interpretation (loc. cit., 1934) is that at a given time the individual unit cell does not possess cubic symmetry, but on the average it is equally probable that any sixteen of the twenty-four available (similar) positions are occupied.

To apply the 'average' method to edingtonite is more difficult, and the number of possible structures is large. Assuming, in the first place, that some thallium ions probably take up positions near those formerly occupied by barium ions, we have attempted to proceed systematically, as far as possible, in locating the remaining thallium ions. We have found one arrangement which explains fairly satisfactorily the observed relative intensities of reflection, and while we do not claim that the structure is uniquely determined, we believe that this must be a close approximation to the true *average*

structure. Table II contains the atomic co-ordinates, and table III a list of observed relative intensities of reflection with corresponding calculated F-values. Fig. 3 represents the structure, and fig. 4 reproduces in convenient form the data contained in table III.

TABLE II. Atomic co-ordinates in substituted edingtonites.

Atom.	Number in cell.	θ_1.	θ_2.	θ_3.	x.	y.	z.
O_A	4	108°	72°	135°	3·0 Å.	2·0 Å.	2·5 Å.
O_B	8	10	70	170	0·3	1·95	3·1
O_C	8	40	22	50	1·1	0·6	0·9
$(SiAl)_1$	2	0	0	0	0	0	0
$(SiAl)_2$	8	60	45	135	1·65	1·25	2·5
Tl_1 or K_1	(2)	180	0	175	5·0	0	3·2
Tl_2 or K_2	(4)	90	90	322	2·5	2·5	5·9

The co-ordinates refer to a tetragonal unit cell with $a = b$ 10·0, c 6·6 Å., and the origin of co-ordinates is a point on a fourfold alternating axis of the space-group D^3_{2d}. θ_1 θ_2 θ_3 are the usual angular co-ordinates ($\theta_1 = 360° \times \frac{x}{a}$, &c.). The group $2(SiAl)_1$ probably contains only silicon atoms; the group $8(SiAl)_2$ probably contains 4 silicon and 4 aluminium atoms. The four thallium (or potassium) ions per unit cell are distributed over the positions $2Tl_1$ (or $2K_1$) and $4Tl_2$ (or $4K_2$) as described in the text. Water molecules are not included in the above table.

In the structure of fig. 3 and table II the tetrahedron chains are identical with those of ordinary edingtonite, but are rotated through a small angle to correspond with the larger cell which is assumed tetragonal with $a = b = 10·0$ Å. (cf. actual axial lengths a 9·94, b 10·00 Å.).

The water molecules cannot be located directly, on account of their small scattering power; they are probably closely associated with the thallium ions.

The thallium ions comprise two groups. The ions of group ($2Tl_1$) lie on the line of intersection of two reflection planes as do the barium ions in ordinary edingtonite, but at a height which differs by 0·9 Å. (cf. figs. 2 and 3). The ions of group ($4Tl_2$) lie on the reflection planes in such positions that they are as far as possible from other positive ions—thallium, silicon, and aluminium. The best agreement between observed intensities and calculated F-values is obtained by assuming that the four thallium ions per unit cell are distributed *uniformly* among the six positions $2Tl_1 + 4Tl_2$. This distribution is discussed in Section IV.

TABLE III. Comparison of observed and calculated intensities for thallium-edingtonite.

sin θ.	*hkl*.	*F*.	*I*.	sin θ.	*hkl*.	*F*.	*I*.
0·051	110	15	1–2	0·066	101	25	nil
0·072	200	90	2–3	0·075	111	125	5–6
0·081	120	25	nil	0·091	201	190	8–9
0·103	220	290	10	0·098	121	15	nil
0·115	130	125	6	0·115	102	20	nil
0·131	230	25	nil	0·116	221	125	4
0·145	400	235	8	0·120	112	245	8
0·150	140	5	nil	0·122	301	15	nil
0·154	330	70	1–2	0·127	131	200	8
0·163	240	75	3–4	0·131	202	65	4–5
0·182	340	40	nil	0·136	122	15	nil
0·185	150	70	3	0·142	231	35	nil
0·196	250	20	nil	0·150	222	125	3–4
0·206	440	290	8	0·154	302	25	nil
0·212	350	35	<1	0·156	401	75	1
0·218	600	25	<1	0·159	141	20	1–2
0·221	160	15	nil	0·159	132	190	7
0·230	260	230	6–7	0·163	331	135	3–4
				0·170	232	30	nil
				0·171	241	210	6
0·054	001	25	nil	0·182	402	160	4
0·108	002	200	8	0·185	142	35	nil
0·161	003	135	5	0·189	341	20	nil
0·215	004	130	3	0·190	332	160	5–6
0·269	005	160	2–3	0·192	242	70	2

In the above table θ is the glancing angle corresponding to Mo $-K_\alpha$ radiation th wave-length 0·71 Å., calculated for the unit cell of ordinary edingtonite. s the observed intensity, and the *F*-values are calculated for the atomic co-dinates listed in table II. The observed intensities are arranged on an bitrary scale in which 1 is very weak and 8 is very strong.

III. *Potassium-edingtonite.*

The true unit cell of potassium-edingtonite, determined by F. A. nnister (loc. cit., 1934), is approximately eight times as large as e unit cell of barium-edingtonite, but there is a well-defined pseudo-ll with axes *a* 9·73, *b* 10·02, *c* 6·68 Å., the true axes being twice as ng. Only a few weak reflections indicate the size of the true unit ll. The pseudo-cell contains, according to the analysis of M. H. ey, 5·76 Si, 4·17 Al, 0·43 Ba, 3·59 K, 20 O, 3·60 H_2O, i.e. in whole mbers $K_4Al_4Si_6O_{20}$ and water. All indices quoted in this paper fer to the pseudo-cell and so are comparable with indices of ordinary ingtonite. The intensities of reflections correspond to tetragonal

symmetry and the space-group (of the pseudo-cell, assumed tetragonal) is D_{2d}^3.

The investigation of potassium-edingtonite is much more difficult than that of the thallium compound, for the following reasons:

(i) All calculations are based on the pseudo-cell, which can only give an approximation to the true structure.

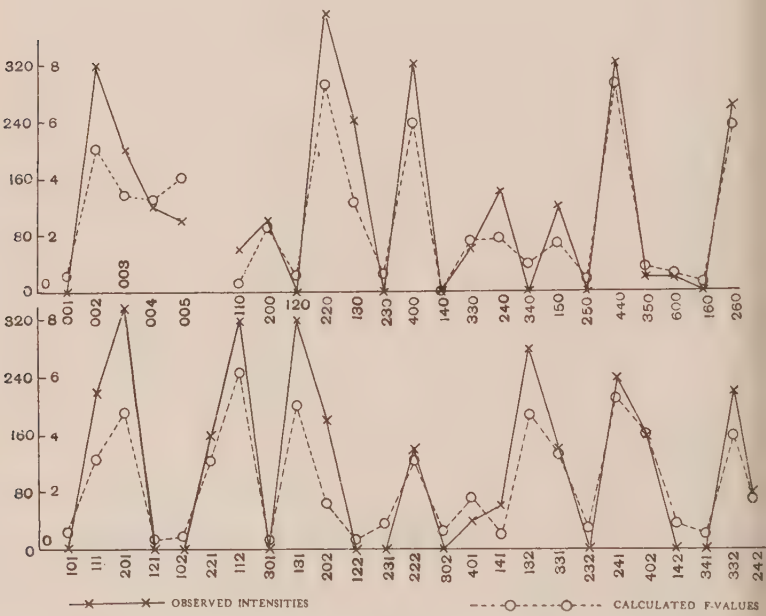

FIG. 4. Comparison of observed intensities of reflection (scale 0 to 8) with calculated F-values (scale 0 to 320) for thallium-edingtonite.

(ii) The scattering power of the potassium ion is only a little greater than that of the other ions in the crystal, and therefore the contribution to the total F made by the four potassium ions per pseudo-cell does not stand out obviously as does the corresponding thallium contribution.

(iii) The water molecules, approximately four per pseudo-cell, may add important contributions to some reflections of low indices and so complicate the search for the correct positions of the potassium ions.

(iv) A small rotation of the tetrahedron chains affects certain calculated F-values to an extent comparable with the total contribution made by potassium ions.

For these reasons we have not been able to proceed as directly , in the case of thallium-edingtonite. It can be shown, however, at simple filling of all similar cavities on the lines of intersection

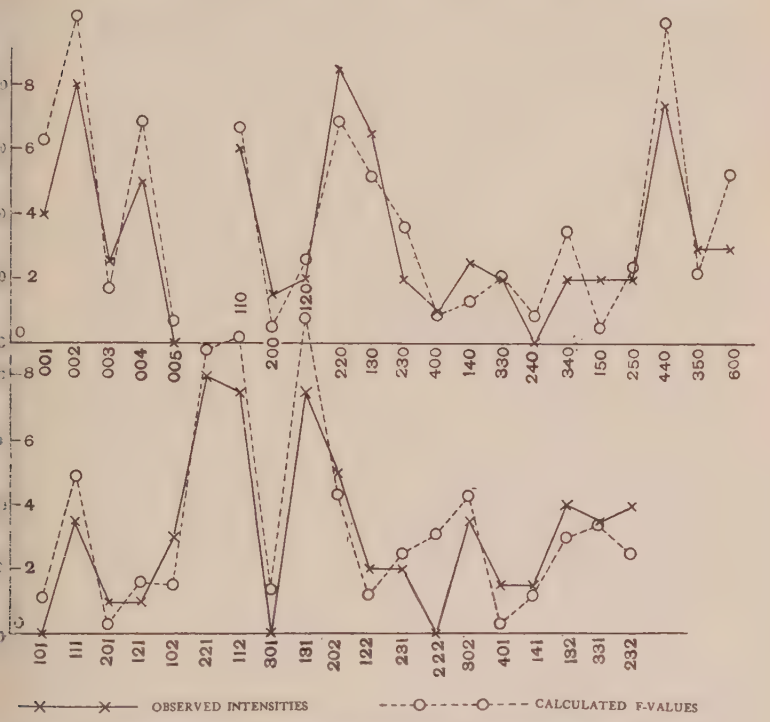

FIG. 5. Comparison of observed intensities of reflection (scale 0 to 8) with calculated F-values (scale 0 to 80) for potassium-edingtonite.

reflection planes (Case i in Section II on thallium-edingtonite) annot explain the observed intensities of reflection. We have also xplored a number of other possibilities, but conclude finally that a ructure identical with that of thallium-edingtonite best explains he observed intensities of reflection. The agreement is definitely nproved if it is assumed that two potassium ions occupy positions K_1 and that the other two potassium ions are distributed uniformly mong the positions $4K_2$. (This distribution is discussed in Section IV.) he agreement is also slightly improved by adding to the F-value for ch reflection one-half of the contribution made by the water mole- ules in ordinary edingtonite to that reflection. It is doubtful whether

this corresponds to reality, although the four water molecules per pseudo-cell could be accommodated since only one half of the positions $4K_2$ are occupied by potassium ions.

Table IV contains a list of observed relative intensities of reflection with calculated F-values for the structure as described above (the contribution from the water molecules being added), and fig. 5 represents these data in graphical form.

TABLE IV. Comparison of observed and calculated intensities for potassium-edingtonite.

sin θ.	*hkl*.	*F*.	*I*.	sin θ.	*hkl*.	*F*.	*I*.
0·051	110	65	6	0·066	101	10	nil
0·072	200	5	1–2	0·075	111	50	3–4
0·081	120	25	2	0·091	201	5	1
0·103	220	70	8–9	0·098	121	15	1
0·115	130	55	6–7	0·115	102	15	3
0·131	230	35	2	0·116	221	90	8
0·145	400	10	1	0·120	112	90	7–8
0·150	140	15	2–3	0·122	301	15	nil
0·154	330	20	2	0·127	131	100	7–8
0·163	240	10	nil	0·131	202	45	5
0·182.	340	35	2	0·136	122	15	2
0·185	150	5	2	0·142	231	25	2
0·196	250	25	2	0·150	222	30	nil
0·206	440	105	7–8	0·154	302	45	3–4
0·212	350	25	3	0·156	401	5	1–2
0·218	600	55	3	0·159	141	10	1–2
				0·159	132	30	4
				0·163	331	35	3–4
0·054	001	65	4	0·170	232	25	4
0·108	002	110	8				
0·161	003	20	2–3				
0·215	004	70	5				
0·269	005	5	nil				

In this table θ is the glancing angle corresponding to Mo$-$K$_\alpha$ radiation o wave-length 0·71 Å., calculated for the unit cell of ordinary edingtonite an therefore approximately correct for the pseudo-cell of potassium-edingtonit to which all indices (*hkl*) refer. The observed intensities (*I*) are arranged on a arbitrary scale in which 1 is very weak and 8 very strong. *F* is calculated fro the atomic co-ordinates listed in table II, but includes *also* one half the contribu tion made by the water molecules to the corresponding reflections in ordinar edingtonite.

IV. *Discussion.*

The evidence presented in support of the suggested structures though not absolutely conclusive, is probably satisfactory. It i rather surprising, however, that the thallium and potassium ion should be distributed differently over the six available positions. I

uld be expected that all the cavities previously occupied by ium ions would again be occupied in the substituted materials, h the additional cations distributed uniformly over the additional itions and so occupying one-half of them on the average. This he distribution chosen for the potassium derivative, but there is doubt that in the case of thallium-edingtonite a better agreement ween observation and calculation is obtained with a uniform ribution of four atoms over all six available positions—i.e. when e weight is given to the group Tl_2. The most reasonable explana- seems to be that the distribution is really the same in both assium and thallium derivatives when substitution is complete—bably positions $2Tl_1$ or $2K_1$ fully occupied, positions $4Tl_2$ or $4K_2$ -half occupied—but that in the actual crystals the apparently rent distributions are due to incomplete replacement of the lent barium atoms.

n 'average' structures so complex as these, there is little point discussing the finer details of atomic environments. It may be h while to remark that in the structure of fig. 3 each ion Tl_1 or has as nearest neighbours two oxygen atoms at distance 2·9 Å. four more at 3·1 Å., and each ion Tl_2 or K_2 has two oxygen is at 2·9 Å. with four more at 3·3 Å. In addition, the water ecules, not included in fig. 3, will certainly be associated with cations.

There are two reasons why the cations should be distributed ng the positions Tl_1 and Tl_2 (or K_1 and K_2) instead of occupying he cavities along the line of intersection of the reflection planes se i, Section II). In the first place, the observed arrangement kits in a more uniform distribution of the positive ions among the gen ions. Secondly, there is the question of the location of the dual valency of the anionic framework, which is probably closely ciated with the aluminium atoms; these atoms cannot be dis-guished directly from silicon atoms, but the most reasonable othetical allocation of silicon and aluminium atoms among the ahedra results in a distribution of residual valency, which is er satisfied by the observed structure than if cations occupied all cavities, as in Case i, Section II.

ur knowledge of the structures is not sufficiently detailed to permit suggestion as to the reason why the true unit cell of the potassium pound is eight times as large as that of the barium and thallium pounds.

I am indebted to Mr. F. A. Bannister for the loan of his X-ra photographs of substituted edingtonites, to Mr. M. H. Hey for supplie of material from which my own photographs were obtained, and t both for helpful discussion of the problem. Most of the work wa carried out in the Physical Laboratories of Manchester University and I wish to thank Professor W. L. Bragg for his continued interes in the research. I am also indebted to the Leverhulme Trustees fo the award of a Fellowship, during the tenure of which this work wa completed.

Some data on the iron-rich hypersthenes.

By N. F. M. Henry, M.A., B.Sc.
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[Read June 6, 1935.]

THE first iron-rich hypersthene reported was from Vittinki in Finland and was described by M. Saxén [1] in 1925. In 1932 N. Sundius [2] showed that the so-called 'iron-anthophyllite' from Tunaberg in Sweden was really a very iron-rich hypersthene. He suggested that two other 'iron-anthophyllites' occurring similarly in the eulysites of Sweden at Bygdsiljum [3] and at Mansjö [4] might also prove to be really iron-rich hypersthenes.

Here chemical and optical data are given for the Mansjö mineral which fits well into the series and proves to be slightly richer in iron than the Tunaberg one. Data are also given for hypersthenes from Loch Duich and from Glen Buchat in Aberdeenshire, while, thanks to the kindness of Professor P. Eskola, it has been possible to obtain a sample of the Vittinki mineral and to complete the data of M. Saxén.

The analyses (table I) show the high percentages of iron in these hypersthenes, while in the Loch Duich mineral the high percentage of MnO replacing FeO is noteworthy.

The Glen Buchat mineral occurs as brown crystals up to 4 mm. long in a biotitic norite, believed to be contaminated, from the Strathdon district of Aberdeenshire. The other four minerals discussed are all from eulysite rocks at four different localities. The Vittinki mineral contains a large number of inclusions of magnetite with small amounts of the accompanying green amphibole and of

[1] M. Saxén, Om mangan-järnmalmfyndigheten i Vittinki. Fennia, Helsingfors, 1925, vol. 45, no. 11, p. 18.

[2] N. Sundius, Über den sogenannten Eisenanthophyllit der Eulysite. Årsbok, Sveriges Geol. Undersökning, 1932, vol. 26, no. 2 [M.A. 6–118].

[3] A. Högbom, Eulysit från Västerbotten. Geol. För. Förh. Stockholm, 1924, vol. 46, p. 711.

[4] H. von Eckermann. The rocks and contact minerals of the Mansjö Mountain. Geol. För. Förh. Stockholm, 1922, vol. 44, p. 267 [M.A. 1–396].

Table 1.

	A.	B.	C.	D.	E.
SiO_2	50·06	47·40	47·68	47·46	46·36
TiO_2	0·32	0·05	0·00	0·03	0·16
Al_2O_3	1·84	1·47	0·69	0·14	0·29
Fe_2O_3	2·06	0·46	1·34	0·34	0·20
FeO	29·39	35·39	37·37	42·23	44·93
MnO	0·19	6·29	2·50	3·88	1·16
MgO	13·63	7·02	6·91	5·05	5·09
CaO	1·43	0·88	2·48	1·05	1·64
$H_2O(+110°)$ ...	0·69	0·09	0·55	0·07	0·03
$H_2O(-110°)$ ...	0·17	0·63			0·07
Total	99·78	99·68	99·52	100·25	99·93

A. Hypersthene from contaminated norite. from Craig Wood, Glen Buchat, Aberdeenshire. Analyst, N. F. M. Henry.

B. Hypersthene in a hypersthene-grunerite-garnet rock, from Druideag Lodge, Loch Duich, Ross-shire. Collected by Prof. C. E. Tilley. Analyst, N. F. M. Henry.

C. Hypersthene from eulysite, from Vittinki, Finland. See M. Saxén (loc. cit). Analyst, N. Sahlbom.

D. Hypersthene from eulysite, from Tunaberg, Sweden. See N. Sundius (loc. cit.). Analyst, R. Mauzelius.

E. Hypersthene from eulysite, from Mansjö Mountain, Sweden. Analyst, N. F. M. Henry.

Table 2.

	A. Glen Buchat.	B. Loch Duich.	C. Vittinki.	D. Tunaberg.	E. Mansjö.
2V ...	51°	68°	70°	81°	83°
α ...	1·715	1·738	1·740	1·750	1·751
β ...	1·728	1·749	1·751	1·760	1·760
γ ...	1·731	1·755	1·757	1·768	1·769
$\gamma-\beta$ ...	0·003	0·006	0·006	0·008	0·009
$\gamma-\alpha$ ...	0·016	0·017	0·017	0·018	0·018
Pleochroism in thin section	Very weak α reddish, β and γ greenish	Very weak α pinkish, β and γ greenish	None	Very weak α yellowish β greenish-yellow γ weak green	Quite marked α reddish-fawn β light fawn γ greenish-grey
Dispersion	Not noticeable	Strong $v>r$	Strong $v>r$	Very strong $v>r$	Very strong $v>r$
Sp. gr.	3·60	3·75	3·77	3·83	3·84

Each Mineral can be picked up with a weak hand magnet.

The Tunaberg data, except the dispersion, are taken from N. Sundius (loc. cit.). For the Vittinki mineral M. Saxén gives γ 1·756 (approx.) and α 1·740; his figure for the specific gravity, 'over 4', is obviously a mistake. The refractive indices were measured by the ordinary immersion method in sodium-light and are $\pm 0{\cdot}002$.

nartz. The Loch Duich mineral, which is green, is accompanied
v grunerite and a garnet, but it often contains small platy in-

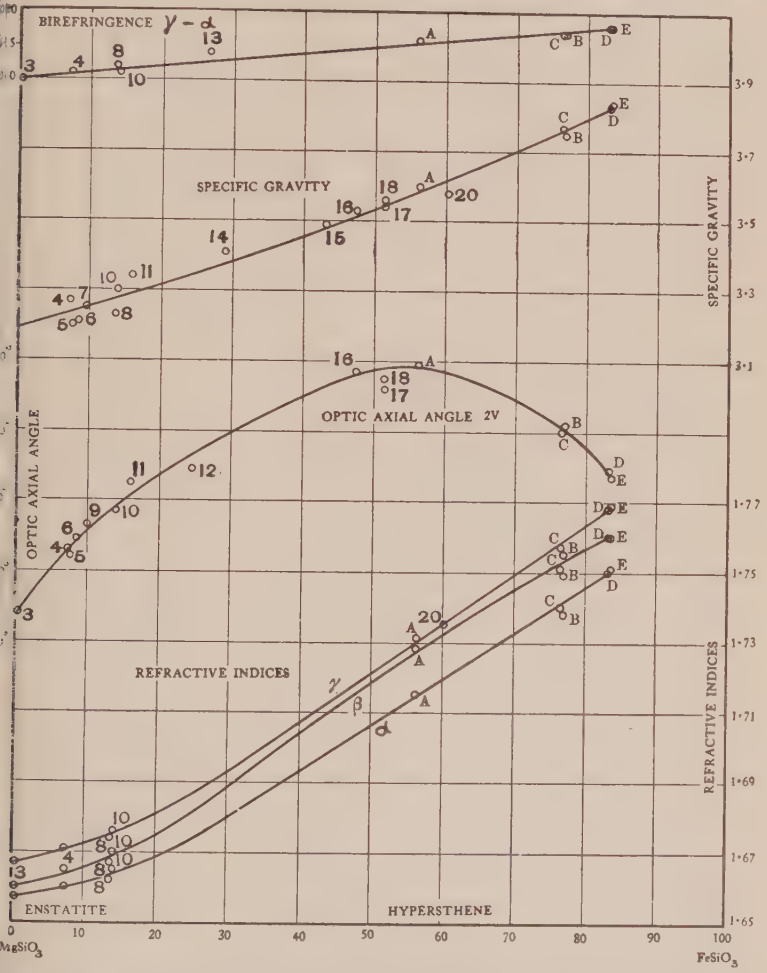

FIG. 1. Variation of optical properties and specific gravity with iron content
e+Mn atomic %) in the orthorhombic pyroxenes.
[Plotted points marked by letters are for data given in the present paper;
ose marked by numbers for data given in R. Walls's graph, this vol., p. 167.]

usions of ilmenite which lie on the plane (100) and are elongated
ong the *b*-axis. According to N. Sundius the Tunaberg mineral,
hich is yellowish-green, is accompanied by manganfayalite and
rnet with occasional grains of grunerite and of a green hornblende,

which occur with a little apatite as inclusions in the iron-rich hypersthene. The Mansjö mineral, which is also green, occurs as large crystals separated often by a mosaic of smaller ones. It contains numerous inclusions of quartz with occasionally a little apatite and green hornblende. In addition to the prismatic cleavage, these iron-rich hypersthenes show a good development of the vertical pinacoidal cleavages, but the (010) one is not so pronounced as the (100).

In the plotting of the results (fig. 1) all constituents are excluded except $(Fe,Mn,Mg)SiO_3$. The various curves were drawn for the present data in the iron half of the diagram, and for the magnesian half data were selected from the tables given by R. Walls,[1] which could be fitted on to reasonably smooth curves. The reference numbers of R. Walls have been retained, but the analyses used have been recalculated in terms of the percentage of (Fe + Mn) atoms out of the total (Fe + Mn + Mg) atoms. The addition of Ca does not improve the plotting in fig. 1 although it was added to the Mg by both R. Walls[1] and A. N. Winchell.[2] In the former case the improvement may have been due to the use of weight percentage, and in the latter case to the over-steepness of the refractive-index curves. The refractive-index lines of A. N. Winchell[2] and of N. L. Bowen and J. F. Schairer[3] are drawn straight to the values of the Bishopville meteorite, but A. N. Winchell later discarded the 2V value of this mineral in his ' Optical mineralogy '. The unreliability of much of the data for enstatites makes the form of the curves at this end of the diagram very doubtful.

It can be seen, however, that the iron-rich hypersthenes fit perfectly into the series as a whole and that there is no indication of the ' mixture-gap ' suggested as a possibility by N. Sundius (loc. cit.). The optic plane remains (100) throughout (taking $a > b$), but the optic axial angle passes through a minimum of approximately 51°. The form of the curves beyond the last fixed point must await the examination of more iron-rich hypersthenes, if these exist.

The text-book explanation that in the enstatite-hypersthene series the intensity of the pleochroism increases with increase in iron content obviously does not hold for the series as a whole, as some

[1] R. Walls, A critical review of the data for a revision of the enstatite-hypersthene series. Min. Mag., 1935, vol. 24, p. 165.

[2] A. N. Winchell, Studies in the pyroxene group. Amer. Journ. Sci., 1923, ser. 5, vol. 6, p. 504 [M.A. 2–219].

[3] N. L. Bowen and J. F. Schairer, The system MgO–FeO–SiO_2. Amer. Journ. Sci., 1935, ser. 5, vol. 29, p. 189.

these iron-rich members are very weakly pleochroic. The occurnce of very varying intensity of pleochroism in hypersthenes in ose proximity to one another in the same rock-mass, which has ten been noted, seems to need some explanation. But an attempt offer such an explanation by comparing the remarks on the leochroism with the analyses of hypersthenes has not been successful. does not seem possible yet to ascribe strong pleochroism to high ntent of Fe_2O_3, MnO, or TiO_2. Perhaps more quantitative measurents of pleochroism might make some chemical explanation of its tensity possible.

In the case of the dispersion of minerals in this series considerable nfusion exists. Text-books contradict one another and there is ften doubt as to whether the acute or the obtuse optic axial angle being referred to. W. Luczizky [1] gives a table showing that most the hypersthenes examined are said to have dispersion $r > v$ (over the acute bisectrix), but some, chiefly in meteorites, are said to ave $v > r$. Original papers on enstatites, such as H. L. Bowman [2] nd K. Johansson,[3] give $v > r$ (over a, the obtuse bisectrix) for these inerals. In the case of the iron-rich hypersthenes examined here e dispersion is $v > r$ and increases with increase of iron to a very arked degree in the Mansjö and Tunaberg minerals. If the enstaes are $v < r$, the hypersthenes $r > v$, and the iron-rich hypersthenes $> r$ (all over a), then there must be two points in the whole series, pproximately at 2V 90° and 50° (negative), where there is no disersion. In agreement with this suggestion the Glen Buchat mineral found to have no discernible dispersion. But many of the older tatements would have to be re-examined before this problem could e cleared up.

The high percentages of the $FeSiO_3$ molecule which are found in ome of these hypersthenes make it desirable that this molecule hould have a name. In recently describing a new natural occurence of monoclinic $FeSiO_3$,[4] Dr. N. L. Bowen [4] puts forward the name clinoferrosilite', adapting the name 'ferrosilite' suggested by H. S. Washington [5] for the normative molecule. It is suggested here that

[1] W. Luczizky, Min. Petr. Mitt. (Tschermak), 1905, vol. 24, p. 140.
[2] H. L. Bowman, Min. Mag., 1900, vol. 12, p. 349.
[3] K. Johansson, Zeits. Kryst. Min., 1894, vol. 23, p. 152.
[4] N. L. Bowen, Ferrosilite as a natural mineral. Amer. Journ. Sci. (in the ress).
[5] H. S. Washington, Prof. Paper U.S. Geol. Survey, 1903, no. 14. p. 90; Min. etr. Mitt. (Tschermak), 1932, vol. 43, p. 63 [M.A. 5–222].

the name 'orthoferrosilite' be used for the $FeSiO_3$ end-member of the orthorhombic pyroxene series, which would then be the enstatite-orthoferrosilite series. It is not intended that the name be used for the Tunaberg or Mansjö iron-rich hypersthenes, but that its possible use as a mineral name be left undecided until more is known about this end of the series. If the new name is adopted it would be possible to define any member of the series in terms of En_xOf_y.

MINERALOGICAL ABSTRACTS

(Vol. 6, No. 4, December, 1935.)

Notices of Books.

Internationale Tabellen zur Bestimmung von Kristallstrukturen.—International tables for the determination of crystal structures.—Tables internationales pour la détermination des structures des cristaux. Vol. 1, *Gruppentheoretische Tafeln.—Tables on the theory of groups.—Tables sur la théorie des groupes.* xii + 452 pp., 464 figs. Vol. 2, *Mathematische und physikalische Tafeln.—Mathematical and physical tables.—Tables mathématiques et physiques.* viii pp. + pp. 453–692, 83 figs. Berlin (Borntraeger), London (G. Bell & Sons), Paris, New York, and Amsterdam, 1935. Price 33 RM. (bound 40 RM.), less 25% foreign; English price £2. 17*s.* 6*d.* (bound).

This indispensable book of reference is the result of the combined and strenuous efforts of all the world's prominent workers in X-ray crystallography to arrive at some definite and standard system. It is the outcome of a conference held in London in 1929 [M.A. **5**–19]. The laborious task of editing such a work has been undertaken by Hermann, with Sir William H. Bragg and M. von Laue as honorary editors, and important contributions have been made by fifteen other workers. Liberal grants towards the cost of printing these complex matter were given by several Academies and Societies, thus enabling the book to be published, and at a reasonable price. The explanations at the beginning of each of the twelve chapters are given in German, English, and French, and tabular matter follows. Chapter V, dealing with the 230 space-groups, is much the longest (p. 80–377). The new Hermann-Mauguin notation [M.A. **5**–202] for the space-groups is given in two forms, full and abridged, with full other modifications for other orientations. These are listed with the Schoenflies and the Rinne-Schiebold-Sommerfeldt symbols [M.A. **5**–201]. The twenty-eight space-groups of the holohedral orthorhombic class (Schoenflies $D_{2h}^1 = V_h^1$ to $D_{2h}^{28} = V_h^{28}$) now have a variety of symbols, e.g. *Pmmm*, *Ccca*, *Fddd*, *Ibam*, &c., which would suggest that they do not even belong to the same crystal-

class. The result is bewildering and confusing, besides being quit unintelligible to the ordinary reader. The new symbols may perhap be of help to X-ray workers, but after all this is only one branch o crystallography. The only system that can eventually be universall adopted must clearly distinguish firstly the crystal system, secondl the thirty-two classes, and thirdly the space-group. Even the simple Schoenflies symbols require an unnecessary effort of memorizatio to connect them with the systems and classes of ordinary crystallo graphy. L. J. S.

Wyckoff (Ralph W. G.). *The structure of crystals. Supplement fo 1930–1934 to the second edition.* American Chemical Society Monograph Series, no. 19 a. New York (Reinhold Publishin Corporation), 1935, 240 pp., figs. 275–341. Price $6.00 [Londo agent, A. F. Bird].

The first edition of this useful book of reference appeared in 192 [M.A. **2**–321] and the second edition in 1931 [M.A. **5**–4]. Th present volume records new data collected from the literature fo the period 1930–1934. The arrangement is on the same lines as, an a continuation of, part II of the second edition. The eleven chapter deal with the structure of the elements, compounds of types RX RX_2, R_2X_3, RX_3 &c., $R_x(MX_3)_y$, $R_x(MX_4)_y$, $R_x(MX_6)_y$, hydrates &c. silicates, and organic compounds. Each chapter contains a tabulate list of substances giving the structure type, cell dimensions, an numbered references to the literature, and further details of ne types of structure are given in the text. The Schoenflies notatio is used for space-groups. The extensive bibliography (62 pp.) give the original titles (or English translation) of papers arranged unde years and authors. The rapid rate at which this subject is growin is shown by the fact that for the year 1933 no less than 546 paper are listed. A detailed index of substances, including mineral name concludes the volume. L. J. S.

Harker (Alfred). *Petrology for students. An introduction to th study of rocks under the microscope.* 7th edition, Cambridg Geological Series, Cambridge (University Press), 1935, vi + 30 pp., 100 figs. Price 8*s.* 6*d.*

This excellent and well-known text-book has been of great servic to several generations of students since it first appeared in 189 The present seventh edition differs only slightly from the sixt edition of 1923 [M.A. **2**–145], the slight diminution in the numbe

pages, from 302 to 300, being accounted for by the complete etting of the type. Only a few minor alterations have been made, l a few new references to the recent literature have been added. e one hundred figures giving clear line-drawings of micro-sections rocks are the same as in the last edition. L. J. S.

RTSCH (H.). *Das Kristallzeichnen auf Grundlage der stereographischen Projektion.* Wien (Julius Springer), 1935, 38 pp., 34 figs. Price 3.60 RM.

This small pamphlet gives a full account of the well-known method drawing crystals from the stereographic projection, as plans on projection plane of the latter and in parallel perspective on any ired plane. The drawing of twinned crystals and drawings repreting the true habit of crystals (depending on the distance of the s from the centre) is then dealt with, as already explained by the hor in recent papers [M.A. **5**–203, **6**–82]. L. J. S.

New Minerals.

ei neue Mineralien. Zentr. Min., Abt. A, 1935, p. 189. [Preliminary announcement.]

ETZENBERG (Robert) & AHLFELD (Friedrich). *Blockit, ein neues Selenerz aus Bolivien.* (Vorläufige Mitteilung.) Zentr. Min., Abt. A, 1935, pp. 277–279.

Blockite is a black mineral with concentric shelly structure found th chalybite, haematite, and limonite in veins in quartzite in the aco silver-lead mine, 30 km., ENE. of Colquechaca. The bright tre quickly tarnishes on exposure to light; streak black, H. $2\frac{1}{2}$, gr. 6·03–6·06. Analysis, Se 69·72, Ni 14·09, Co 2·45, Cu 6·70, 1·29, Pb 0·35, Hg 1·95, Ag 1·73, Pt metals 0·022, insol. 1·28 = 99·58, rresponds with $(Ni,Cu)Se_2$. This differs from penroseite [M.A. **3**–2], probably from the same locality, in containing more selenium d less lead. Alteration products of blockite are a reddish crystale nickel selenate (to be described later under the name ahlfeldite) d white needles probably of selenolite (SeO_2). L. J. S.

LACHE (Charles). *Lindgrenite, a new mineral.* Amer. Min., 1935, vol. 20, pp. 484–491, 6 figs. [Cf. preliminary account, M.A. **6**–54.]

The monoclinic crystals of tabular pseudo-orthorhombic habit ve $a:b:c = 0·5941:1:0·5124$, $\beta = 87° 48'$ [incorrectly given as

77° 48′ in M.A. **6**–54] with fourteen forms. X-ray measurements gave a unit cell a 8·45, b 14·03, c 7·04, β 87½°, containing $Cu_{12}(MoO_4)_8(OH)_8$. Sp. gr. 4·26, H. 4½; α 1·930, β 2·002, γ 2·020, $\gamma = b$, $\alpha : c = -7°$, 2V 71°, negative. Analysis by F. A. Gonyer, MoO_3 50·97, CuO 40·62, Fe_2O_3 1·43, H_2O 3·30, insol. 3·34 = 99·66, agrees with $2CuMoO_4.Cu(OH)_2$ [not $CuMoO_4.Cu(OH)_2$]. L. J. S.

Carobbi (G.). *«Mercallite» nuovo minerale fra i prodotti dell'attività fumarolica vesuviana del 1933.* Rend. R. Accad. Lincei, Cl. Sci. fis. mat. nat. Roma, 1935, ser. 6, vol. 21, sem. 1, pp. 385–393, 6 figs.

Analysis of a sky-blue saline stalactite from the crater of Vesuvius gave HSO_4 65·68, SO_4 4·25, K 21·99, Na 3·67, Cu 0·77, Ca 0·25, Al 0·12, H_2O (over $CaCl_2$) 1·81, H_2O (at 110°) 0·64, insol. in water 0·57 = 99·75. This corresponds with $KHSO_4$ together with 6–7% $K_2SO_4 + Na_2SO_4$. Minute (0·01–0·04 mm.) orthorhombic crystals of tabular habit, with α 1·445, γ 1·491, 2V 56°, positive, sp. gr. 2·307–2·310, have characters identical with artificial $KHSO_4$ and are named mercallite. Misenite, which was described by A. Scacchi in 1849 as $KHSO_4$, was afterwards proved by F. Zambonini in 1907 to be the menoclinic double salt $K_2SO_4.6KHSO_4$. The material now described also contains a few minute monoclinic crystals of prismatic habit with γ' 1·466, 2V 33°, positive, extinction-angle 16°, identical with the artificial $K_2SO_4.6KHSO_4$. This is referred to misenite and accounts for the presence of K_2SO_4 shown in the analysis. L. J. S.

Nováček (R.). *Study of some secondary uranium minerals. (Etudes sur quelques minéraux secondaires de l'uranium.)* Věstník Král. České Spol. Nauk (Mém. Soc. Roy. Sci. Bohême), Cl. 2, 1935, no. 7, 36 pp., 2 pls., 2 text-figs.

A detailed revision of the minutely crystallized sulphates and silicates, which are often incorrectly labelled in collections. Several new micro-chemical analyses are given. Johannite from Jáchymov, Bohemia [M.A. **6**–95], gave SO_3 16·59, UO_3 61·34, CuO 8·07, H_2O 13·84 = 99·34, corresponding to $CuO.2UO_3.2SO_3.7H_2O$. Uranopilite in six analyses of material from different localities gave $6UO_3.SO_3.16$ (or 17)H_2O; α 1·623, β 1·625, γ 1·633, $\beta : c = 18°$. The bright yellow uranopilite changes on partial dehydration to greyish-brown *β-uranopilite*, $6UO_3.SO_3.10H_2O$, with straight extinction and α 1·72, β and γ 1·76. Zippeite gave $2UO_3.SO_3.5$–$6H_2O$; α 1·575–1·636, β 1·615–

1·694, γ 1·646–1·732. Uranotile from Jáchymov gave (on 7·5 mg.) SiO_2 13·11, UO_3 66·29, CaO 7·32, H_2O 12·87 = 99·59, agreeing with the usual formula $CaO.2UO_3.2SiO_2\,6H_2O$; but the optical data (α 1·665, β 1·686, γ 1·696, $c:\gamma = 41°$ Na) differ from those of typical uranotile, and the material is distinguished as *β-uranotile*. Cuprosklodowskite from Jáchymov gave (on 4·5 mg.) SiO_2 13·40, UO_3 64·96, CuO 8·99, H_2O 11·72 = 99·07, corresponding to $CuO.2UO_3.2SiO_2.6H_2O$; the optical data (α 1·654, β and γ 1·664) differ slightly from those of the original cuprosklodowskite [M.A. **5**–389], and the name *jachymovite* is provisionally applied. L. J. S.

Jungemach (H.). *Sur certains minéraux sulfatés du Chili.* Bull. Soc. Franç. Min., 1935, vol. 58, pp. 97–221, 1 pl., 41 text-figs.

Full details are now given of a re-examination that has been made [M.A. **5**–390] of the collection of secondary sulphates, derived from pyrite, from Tierra Amarilla and Sierra Gorda, in the University of Strasbourg, which were described by G. Linck in 1888. Many new crystal-forms are noted. The minerals described are: botryogen (anal. I, $Fe_2O_3.2MgO.4SO_3.15H_2O$); hohmannite (II, $Fe_2O_3.2SO_3.7H_2O$); quenstedtite (III, $Fe_2O_3.2SO_3.6H_2O$); copiapite (IV, $2Fe_2O_3.5SO_3.17H_2O$; a crystallographically aberrant form is called *pseudo-copiapite*); melanterite; römerite; coquimbite (V, not in close agreement with generally accepted formula $Fe_2O_3.3SO_3.9H_2O$; unit cell a 10·85, c 17·03 Å); *paracoquimbite* (VI, unit cell a 10·90, c 51·15 Å., $a:c$ = 1 : 4·6928; rhombohedral paracoquimbite forms regular intergrowths (syntaxy) with hexagonal coquimbite); quenstedtite (VII, $Fe_2O_3.3SO_3.10H_2O$); *amarillite* (VIII, $Fe_2O_3Na_2O.4SO_3.12H_2O$); *leucochalcite* (IX, $Fe_2O_3.4SO_3.5H_2O$); *lapparentite* (X, $Al_2O_3.2SO_3.10H_2O$); sulphur; chalcanthite; apatelite?; natrojarosite or utahite?; and voltaite.

	SO_3.	Fe_2O_3.	Al_2O_3.	MgO.	Na_2O.	H_2O.	Total.	Sp. gr.
I.	38·10	20·63	—	10·21	—	29·47	98·41	2·094
II.	36·75	36·81	—	—	—	25·88	99·44	—
III.	37·55	37·31	—	—	—	25·14	100·00	2·186–2·189
IV.	38·89	31·92	—	—	—	29·19	100·00	2·134
V.	42·37	28·94	trace	—	—	28·48	99·79	2·096
VI.	41·38	29·79	trace	—	—	28·69	99·86	2·109–2·117
VII.	39·37	27·88	—	—	—	31·69	98·94	2·147
VIII.	43·59	21·39	—	—	7·14	28·45	100·57	2·194–2·197
IX.	56·97	28·06	—	—	—	15·02	100·05	2·100
X.	35·81	3·06	20·91	—	—	40·35	100·12	2·068–2·072

L. J. S.

Lapparent (Jacques de). *Les étapes du métamorphisme des émeris de Samos.* Compt. Rend. Acad. Sci. Paris, 1935, vol. 201, pp. 154–157.

These emeries are essentially diaspore-emeries, in which the crystallization of the diaspore was contemporaneous with the occurrence of a shearing stress in the original aluminous material which had attained a pisolitic stage. When this stress relaxed spinel was formed, associated with a new mineral distinct from corundum for which the name *taosite* is suggested, the Al_2O_3 being derived from the diaspore of which some crystals remain oriented according to the original stress. Taosite is uniaxial negative, strongly pleochroic (clear yellow and reddish-brown), n approximately 1·78, $\omega - \epsilon$ 0·035. It occurs as laminae included in spinel crystals parallel to the octahedral faces. White mica and chloritoid are also present. [Cf. M.A. **5**–526.] C. A. S.

Lapparent (Jacques de). *Sur un constituant essentiel des terres à foulon.* Compt. Rend. Acad. Sci. Paris, 1935, vol. 201, pp. 481–483.

A light green absorbent fuller's earth, for which the name *attapulgite* is proposed, has been found at Mormoiron (Vaucluse, France) and Attapulgus (Georgia, U.S.A). It differs from both the kaolinite-halloysites and the montmorillonites. Analyses of samples from the two localities show respectively: SiO_2 53·6, 53·7; Al_2O_3 10·6, 9·0; Fe_2O_3 6·5, 3·6; FeO 0·3, 0·2, MgO 4·6, 9·6; CaO 2·1, 1·2; Na_2O 0·8, 0·9; K_2O 0·5, 0·5; H_2O- 11·6, 9·7: H_2O+ 9·4, 11·6, indicating as the general composition $x[9SiO_2.6(Mg,Fe'',Ca)O.12H_2O] + y[9SiO_2.2(Al,Fe''')_2O_3.12H_2O]$, where $x:y$ is less than one (if greater the mineral is a sepiolite). The dehydration curves closely resemble those of the palygorskites, from which it differs in containing no kaolinite. It is suggested that it has originated from an alkali-magnesian mica, and that the absorbent properties are due to part of the water being zeolitic. C. A. S.

[Godlevsky (M. N.)] Годлевский (М. Н.). Айдырлит—новый минерал. Godlevsky (M. N.). *Das neue Mineral Aidyrlit.* Зап. Всеросс. Мин. Общ. (Mém. Soc. Russe Min.), 1934, ser. 2, vol. 63, pp. 338–345, 2 figs. (Russ. with Germ. summary.)

This occurs as small veins in Lower Carboniferous limestone near serpentine and granite in the nickel deposit at Aidyrly, near Kvarken, Orenburg, Urals. It is turquoise-blue with dull lustre, and is col-

bidal with conchoidal fracture; H. 2½. It is optically isotropic or ebly birefringent, *n* 1·533–1·545, but ranging from 1·509 to 1·573. distinctive X-ray pattern is shown. Analysis gave SiO_2 25·15, l_2O_3 28·75, Cr_2O_3 0·09, Fe_2O_3 0·06, NiO 17·59, CoO 0·13, CuO 1·52, gO 0·39, CaO 0·53, $K_2O + Na_2O$ 0·10, P_2O_5 0·03, $H_2O(+105°)$ 19·07, $I_2O(-105°)$ 5·98, total '99·40'. An approximate formula is $2NiO.Al_2O_3.3SiO_2.7\frac{1}{2}H_2O$, but the composition is variable. L. J. S.

Ho (T. L.). *Note on some rare earth minerals from Beiyin Obo, Suiyuan.* Bull. Geol. Soc. China, 1935, vol. 14, pp. 279–282, 1 pl.

The recently discovered deposit of iron ore at Beiyin Obo, 150 km. orth of Paoto in Inner Mongolia, contains numerous fluorite veins, p to one metre thick, which extend into the surrounding limestone. he dark purple fluorite-rock is very fine-grained, and contains rains of magnetite, pyrite, baryte, and of two undetermined minerals, lled *beiyinite* and *oborite*. These are greenish-yellow in micro- ctions, and the minute, strongly birefringent grains are surrounded y a colourless halo in the violet fluorite. A laborious separation ielded 0·96 % from the fluorite-rock. Beiyinite is optically uniaxial, sitive, ϵ 1·7910, ω 1·7169(Na), with perfect basal cleavage, and is erhaps tetragonal; sp. gr. 4·829, H. 4½. It is insoluble in HCl, ut soluble with effervescence in hot concentrated H_2SO_4, and is nfusible. Oborite is optically uniaxial, positive, ϵ 1·8500, ω 1·7948 Na), with perfect rhombohedral cleavage, *cr* 51·2°; sp. gr. and ardness the same as for beiyinite, but it is more insoluble in acid. pectroscopic analysis of the fluorite-rock showed La, Ce, Yt, Er, hich are assumed to be present in these two minerals. L. J. S.

Reißner (R.). *Über einen kobalthaltigen Oligonspat.* Zentr. Min., Abt. A, 1935, pp. 170–173.

A specimen of unknown locality shows quartz and chalybite with ne veins of a peach-blossom-red. A micro-analysis on 3 mg. of the ast gave CO_2 41·04, FeO 25·10, MnO 11·90, MgO 10·07, CoO 9·10, aO 2·43, ZnO 0·40, corresponding with $CoCO_3$ 14·44 %. The name obalto-sphaerosiderite on cobalt-oligonspar is suggested [but the xamination is not complete and the material was intimately mixed ith chalybite]. L. J. S.

Tolliffe (Fred). *A study of greenalite.* Amer. Min., 1935, vol. 20, pp. 405–425, 5 figs.

The greenalite-rock at Biwabik in the Mesabi iron range, Minnesota, onsists of: granules of isotropic green greenalite, *n* 1·675, sp. gr.

2·85–3·15; granules of a mottled anisotropic green material, called *metagreenalite* and believed to be the crystalline equivalent of greenalite; a light-coloured fibrous mineral ('mineral X'), α 1·580, γ 1·615, containing SiO_2 48·7, Fe_2O_3 11·6, FeO 23·1, MgO 9·9, H_2O 6·7 %; quartz as a fine mosaic forming the matrix of the granules; iron oxides as specks in the granules and the matrix. Pure material could not be separated for analysis, but from micrometric and chemical analyses of the rock and 'mineral X' the composition of greenalite and of metagreenalite is deduced as $3FeO.4SiO_2.2H_2O$. The origin and alteration of greenalite are discussed. L. J. S.

Kerr (Paul F.). *U-galena and uraninite in Bedford, New York, cyrtolite.* Amer. Min. 1935, vol. 20, pp. 443–450, 3 figs.

A polished slab of cyrtolite showed specks of galena (with the usual characters of the mineral), minute veins and scattered grains of uraninite, and films of autunite. It produces a diffused picture on a photographic plate. Analysis gave Pb 0·33, S 0·05 %. E. Muench [M.A. **5**–331] found U 7·29, Pb 0·374 %; and Baxter and Alter [M.A. **5**–331] determined the atomic weight of the lead as 205·92. This lead isotope Pb^{206} is evidently radiogenetic lead from uranium, and the galena it forms is called U-galena. [Cf. M.A. **6**–34.]

L. J. S.

De Leenheer (L.). *Trieuiet, een nieuw kobalt mineraal.* Natuurwetenschappelijk Tijdschrift, Gent, 1935, vol. 17, pp. 91–95, 2 figs.

A new analysis by V. Cuvelier of the mineral from Étoile mine, Katanga, which has been compared with heterogenite and schulzenite [M.A. **1**–243] gave Co_2O_3 53·58, CoO nil, CuO 22·63, SiO_2 1·50, CO_2 1·36, H_2O 20·16 = 99·23. After deducting associated malachite and chrysocolla, this gives a formula $2Co_2O_3.CuO.6H_2O$, thus differing from heterogenite and schulzenite, which contain both Co_2O_3 and CoO. It is therefore considered to be a distinct mineral, and is named trieuite. It is black and colloidal, isotropic in reflected light, and when heated loses water and oxygen. [Cf. mindigite, M.A. **6**–52.]

L. J. S.

De Leenheer (L.). *Over stainieriet.* Natuurwetenschappelijk Tijdschrift, Gent, 1935, vol. 17, pp. 44–48, 4 figs.

Stainierite [M.A. **4**–248, 347] has been found at another locality in Katanga, namely at Luisha. This occurs in druses with a shining

amillated surface; sp. gr. 4·32, H. 4½. Analysis, Co_2O_3 72·19, $_2O_3$ 9·93, Al_2O_3 7·22, H_2O 10·66, agrees with the formula (Co,Fe, $)_2O_3.H_2O$ previously given. But the mineral is not homogeneous. consists of a fine granular aggregate of hydroxides of cobalt ($Co_2O_3.H_2O$), iron, and aluminium, and has been derived from an npure sphaerocobaltite. L. J. S.

Achiardi (G.). *Dell'ammonioborite di W. T. Schaller.* Proc. Verb. Soc. Toscana Sci. Nat., 1934, vol. 43, pp. 82–89.

Doubt is thrown on Schaller's optical description and chemical nalysis of ammonioborite. His analysed and optically examined aterial appears to have been altered larderellite. There is, however, second ammonium borate present in many 'bechilite' specimens, hich is probably produced by the action of hot water or steam larderellite, and it is suggested that the name ammonioborite be nsferred to this. [Cf. M.A. **5**–146, 391.] M. H. H.

élon (J.). *Analyse et propriétés optiques de la thoreaulite.* Bull. Acad. Roy. Belgique, Cl. Sci., 1935, pp. 473–475.

Analysis of thoreaulite [M.A. **5**–389] gave Ta_2O_5 72·83, SnO_2 21·88, O_2 1·85, Al_2O_3 1·02, Fe_2O_3 0·50, CaO 1·28, Nb_2O_5, Sb_2O_3, MnO, gO traces, total 99·36, confirming the formula $Ta_2O_5.SnO_2$. Mono- nic with cleavage (100) perfect, (011) imperfect. Optic axial ane (010), acute positive bisectrix at 63° to the normal to (100), V 25°, mean n 2·38 about. L. J. S.

Topographical Mineralogy.

ines: year 1933. List of mines in Great Britain and the Isle of Man. Mines Department, London, 1934, vii + 358. Price 10*s*. [Cf. M.A. **5**–487.]

ourant (A. E.) & Warren (J. P.). *Minerals and mining in the Channel Islands.* Trans. Soc. Guernesiaise, 1934, vol. 12 (for 1933), pp. 73–88, 4 pls.

Historical notes on unsuccessful mining ventures in the Channel slands between 1833 and 1845. The most important deposit was silver-lead vein in hornblende-granite on the island of Sark. The rgentiferous galena (with cerussite, anglesite, and leadhillite near ne surface) passed northwards into silver ore, with cerargyrite above nd argentite, pyrargyrite, &c., below, in a gangue of calcite and uartz. Another vein in the Sark granite carried pyrite with some

chalcopyrite. Attempts were also made to work copper ore in Herm and Guernsey. At L'Etacq in Jersey thin veins at the contact of granite and pre-Cambrian shale carry molybdenite, pyrite, chalcopyrite, &c. L. J. S.

Mourant (A. E.). *Mineralogical notes.* Bull. Soc. Jersiaise, 1933, vol. 12, pp. 100–102; 1934, vol. 12, pp. 238–240.

Brief notes on new finds of minerals in the Channel Islands, with mention of vivianite, atacamite, prehnite, epistilbite [M.A. **6**–130], covelline, tridymite, bindheimite, ankerite, zircon, &c. L. J. S.

Fischer (Walther) with Pank (Martin) & Schmidt (Johannes). *Die Mineralien im Syenite des Plauenschen Grundes bei Dresden.* Sitzungsber. Abhandl. Naturwiss. Gesell. Isis, Dresden, 1934, Festschrift, pp. 126–170, 1 fig. (plan).

Several quarries are worked in this well-known rock and have yielded a considerable variety of minerals. The rock contains small crystals of sphene, and basic streaks contain various copper minerals. Pegmatite nests and veinlets, with more quartz and orthoclase and less hornblende than the normal rock, contain orthite, malacon, beryl, tourmaline, scheelite, molybdenite, &c. Crevices in the rock, carrying crystallized minerals, are distinguished as epidote-quartz, analcime-calcite, laumontite-calcite, baryte-calcite-quartz, amethyst, and aragonite crevices. A long list of references to the literature for the past hundred years is added. L. J. S.

Bader (Henri). *Beitrag zur Kenntnis der Gesteine und Minerallagerstätten des Binnentals.* Schweiz. Min. Petr. Mitt., 1934, vol. 14, pp. 319–441, 1 pl. (map).

A detailed account is given of the rocks, ortho-, para-, and mixed gneisses and schists, amphibolites and ophiolites, together with a petrographical map of the Binn district in Switzerland. The mineral deposits in the various kinds of rocks are dealt with under the several localities. The most prolific is in the dolomite of the Lengenbach, and full descriptions from the literature are given of the 41 minerals recorded from that locality. New crystal-forms are given for untwinned rathite (wiltshireite). A bibliography of 193 items is added. L. J. S.

ARROBBI (Guido) & ALFANI (Maurizio). *Augite diopsidica dei blocchi calcarei metamorfosati del Monte Somma.* Ann. R. Osservatorio Vesuviano, 1934, ser. 4, vol. 3, pp. 45–59, 2 figs.

Goniometric measurements are given of the blackish-green crystals prismatic habit. Sp. gr. 3·214, α 1·670, β 1·678, γ 1·702, 2V 58° (Na), $\gamma = 45–48°$ (for λ 656–486). Analysis gave SiO_2 52·77, Al_2O_3 90, Fe_2O_3 0·45, Cr_2O_3 0·50, Sb_2O_3 0·03, FeO 3·35, MnO 0·63, PbO 18, CuO 0·05, ZnO 0·04, NiO trace, MgO 15·14, CaO 24·50, SrO, aO traces, H_2O 0·26 = 100·80, agreeing closely with the formula of arren and Biscoe [M.A. **5**–186]. Analyses are also given of the ssociated forsterite and calcite. L. J. S.

LFANI (Maurizio). *Sulla presenza della glauberite e della polyhalite fra i prodotti dell'attività fumarolica vesuviana del maggio-giugno 1933.* Ann. R. Osservatorio Vesuviano, 1934, ser. 4, vol. 3, pp. 73–82.

White saline crusts, consisting mainly of halite and sylvine, from e crater of Vesuvius were analysed (Ti, Rb, Cs traces) and the inerals present determined under the microscope and by recrystal- ing the aqueous solutions. Alunogen and glauberite were found one sample, and polyhalite in another. Glauberite and polyhalite e new records for Vesuvius. L. J. S.

LFANI (Maurizio). *Sui sali di ferro delle fumarole vesuviane a cloruri e solfati alcalini del maggio-giugno 1933.* Ann. R. Osservatorio Vesuviano, 1934, ser. 4, vol. 3, pp. 83–101, 1 pl.

Analysis of a yellow crust from the crater of Vesuvius gave Cl 3·80, SO_3 2·90, Fe_2O_3 (total iron) 19·36, Na_2O 11·79, K_2O 19·41, $_2O$ 23·90, total less O for Cl 99·66. Under the microscope crystals halite and sylvine were identified, and other crystals are perhaps $SO_4.6H_2O$. L. J. S.

OKTA (Jaroslav). *Příspěvky k mineralogii země Moravskoslezské.* [Contribution to the mineralogy of Moravia-Silesia.] Spisy vydávané přírodovědeckou fakultou Masarykovy University, Brno, 1935, no. 201, 16 pp., 1 fig. (Czech with German résumé.)

Chromite from Drahonín, near Tišnov in central Moravia gave $_2O_3$ 42·91, Cr_2O_3 26·59, Fe_2O_3 0·85, FeO 12·87, MgO 16·98 = 00·20, sp. gr. 4·004, corresponding with 1 mol. chromite and 2·34 inel. Manganosiderite as concretions from Střílky gave FeO

42·63, MnO 8·44, MgO 3·51, CaO 4·18, CO_2 38·86, H_2O 0·04, insol. 2·58 = 100·24, sp. gr. 3·523. A colloidal silicate of alumina rich in copper, from Zuckmantel in Czech Silesia, which was described by E. F. Glocker in 1853 as allophane, is shown by analysis to be not quite homogeneous; SiO_2 22·61, Al_2O_3 6·22, Fe_2O_3 0·10, FeO 1·10, CuO 28·11, MgO 0·96, CaO 2·68, $Na_2O + K_2O$ 1·07, CO_2 4·21, H_2O 33·14 = 100·20, sp. gr. 2·174, n 1·58–1·59. Rutile from Dobrá Voda, near Velké Meziříčí in western Moravia, is partly altered to ilmenite and contains traces of tin; analysis corresponds with rutile 85·49, ilmenite 13·93, haematite 0·58%. Wollastonite from Nedvědice of a pale rose colour gave $CaSiO_3$ 92·42, $FeSiO_3$ 3·47, $MnSiO_3$ 0·15, admixed calcite 3·96 %, sp. gr. 2·893, β 1·631. F. S.

Heron (A. M.). *The mineral resources of Rajputana.* Trans. Mining & Geol. Inst. India, 1935, vol. 29, pp. 289–408, 4 pls., 1 text-fig.

Rajputana is not rich in mineral wealth. Many localities are recorded for the several minerals dealt with in an alphabetical list, but few of them are of economic importance. Besides building materials, coal, fuller's earth, steatite, gypsum, and salt are now worked; and ores of lead, zinc, copper, iron, and wolfram were formerly worked on a small scale. L. J. S.

Coates (J. S.). *The geology of Ceylon.* Ceylon Journ. Sci. (Spolia Zeylanica), Sect. B, 1935, vol. 19, pp. 101–187, 1 map (12 miles to 1 inch), 12 pls., 7 text-figs.

Nine-tenths of the area is occupied by Archaean crystalline rocks, including khondalite, charnockite, leptynite, granulite, quartzite, gneiss, and schist, which are often garnetiferous. These are intersected by pegmatites of two types: a white variety rich in accessory minerals, zircon, radioactive and gem minerals; and a red variety poor in accessory minerals. There are also dikes of dolerite, peridotite, and pyroxene-scapolite-rock. A small area of Jurassic and a strip of Miocene rocks occur on the NW. coast. Economic minerals include graphite, mica, thorianite, gem minerals, and ilmenite, monazite, and zircon sands. Some opaque corundum has been found in the crystalline rocks and there is a corundum-fibrolite-rock; but all the gem minerals appear to be derived from the white pegmatite. There is no evidence that any have come from the bands o

ystalline limestone. They include corundum of various colours with pphire predominating, beryl (aquamarine), chrysoberyl, zircon, spinel various colours, tourmaline, topaz, quartz (amethyst, citrine and her varieties), garnets (hessonite, pyrope, almandine, spessartine, odolite). These are worked mainly in the river gravels, with a few rkings in terrace gravels and in eluvial material on the hill sides. onstone is worked in a band of sheared quartz-orthoclase-rock, ich is probably an acid phase of the pegmatite. [Cf. M.A. **4**–312.]

L. J. S.

ô (Tei-ichi). *Morphological studies of Japanese minerals.* (In Japanese.) Memorial volume for N. Fukuchi. Beiträge zur Mineralogie von Japan, Neue Folge, 1935, no. 1, pp. xiv + 259, 1 pl., 298 text-figs. Tokyo (Min. Inst. Imp. Univ.). Price 10 yen.

A collection of seventy-six papers on the crystallography of Japanese d Korean minerals. Many excellent drawings of crystals are given the plate shows a portrait of N. Fukuchi [1877–1934]. The lume is a continuation of 'Beiträge zur Mineralogie von Japan', s. 1–5, 1905–15 [M.A. **1**–132], and is a first contribution towards Third edition of T. Wada's 'Minerals of Japan' [M.A. **1**–63].

R. O.

ARADA (Zyunpéi). *On some minerals from Hokkaidô, Japan I, II.* Journ. Assoc. Min. Petr. Econ. Geol., 1932, vol. 8, pp. 156–160, 207–211 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 1.

Rhodochrosite, Sikaribetu mine, Isikari prov.—Pale pink rough ombohedra from veins of lead ore gave I. Manganocalcite, Todo-ki mine, Isikari prov.—Pale pink as a gangue mineral in a gold-ver-quartz vein; paler material gave II, and darker III.

	CO_2.	FeO.	MnO.	MgO.	CaO.	Insol.	Total.	Sp. gr.	ω.	ϵ.
I. ...	38·40	3·83	55·74	0·59	1·29	0·03	99·88	3·646	1·803	1·584
II. ...	42·78	0·29	3·19	0·32	52·83	0·50	99·91	2·741	1·6611	1·4907
III. ...	43·39	0·29	7·67	0·47	48·26	—	100·08	2·812	1·680	1·502

Baryte, Teiné mine, Isikari prov.—Thick-tabular crystals with tive tellurium from a gold vein; $a : b : c = 0{\cdot}815 : 1 : 1{\cdot}314$, sp. gr. 512, α 1·6345, β 1·6366, γ 1·6468. Baryte and calcite are described om other localities.

L. J. S.

Harada (Zyunpéi). *On the crystal form of realgar from Saimoku, Gunma pref.* Journ. Assoc. Min. Petr. Econ. Geol., 1932, vol. 8, pp. 212–214 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 1.

Short-prismatic crystals showing twelve forms gave $a:b:c = 0{\cdot}7197:1:0{\cdot}4866$, $\beta = 66° 10\frac{1}{2}'$. L. J. S.

Kamiyama (Teiji). *Diopside from Hôki-zawa, Kanagawa prefecture.* Journ. Geol. Soc. Tokyo, 1934, vol. 41, pp. 20–24 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstract p. 11.

The crystals show eight forms; α 1·674, β 1·685, γ 1·703, $c:\gamma = 40°$. Analysis gave SiO_2 51·61, Al_2O_3 2·53, Fe_2O_3 2·61, MgO 17·15, CaO 24·43 = 98·33. L. J. S.

Kamiyama (Teiji). *Vesuvianite from Hôki-zawa, Kanagawa prefecture.* Journ. Geol. Soc. Tokyo, 1934, vol. 41, pp. 183–188 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 12.

Twelve crystal-forms are noted. Analysis of material from Siroisi-zawa gave I, from Zare-no-sawa II.

	SiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.	Na_2O.	K_2O.	Ign.	Total.
I. ...	35·48	15·40	5·56	1·57	0·10	2·01	34·90	1·15	0·63	2·41	99·21
II. ...	36·29	16·09	5·23	1·12	0·10	2·46	34·91	1·04	0·60	1·92	99·76

L. J. S.

Koike (Sirô). *Contact minerals from Tokiwa, Nagano prefecture, II.* Journ. Geol. Soc. Tokyo, 1934, vol. 41, pp. 189–193 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 12.

Diopside of three types gave:

	SiO_2.	Al_2O_3.	Fe_2O_3.	MgO.	CaO.	α.	β.	γ.	2V.	$c:\gamma$.
I.	53·66	2·51	3·13	16·73	25·15	1·675	1·680	1·702	58°	37°
II.	54·30	0·79	0·80	17·71	25·73	1·668	1·678	1·696	57	36
III.	54·51	0·83	0·74	17·85	25·75	1·667	1·676	1·698	57	36

L. J. S.

Watanabe (Takeo). *Contact minerals from Tokiwa, Nagano prefecture, III.* Journ. Geol. Soc. Tokyo, 1934, vol. 41, pp. 457–460, 1 pl. (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 12.

Clinohumite, α 1·637, β 1·649, γ 1·668, 2V 72°, positive; $\perp$ (001):

= 9°; pleochroism, α golden yellow to brown, β almost colourless, light yellow. Pargasite, α' 1·652, γ' 1·664, 2V 63°, positive, $\gamma = 29°$; pleochroism, α colourless, β light yellow, γ light green.

L. J. S.

ARLOW (N. E.). *A list of minerals known to occur in Southern Rhodesia.* Occasional Papers of the Rhodesian Museum, 1934, no. 3, pp. 41–48.

This list is based upon F. P. Mennell's 'Minerals of Rhodesia' 921) but records the following additional species:—alunogen, mazonstone, bieberite, bixbyite, chabazite, chloanthite, copiapite, rgusonite, gmelinite, maufite, niccolite, stibiotantalite, tetradymite, nadinite, wittichenite, zöblitzite. None of these occurrences ssesses any economic importance. In all 226 mineral species are ted, several of which are marked as doubtful. S. J. S.

ACGREGOR (A. M.). *The geology of the Makaha gold belt, Mtoko district.* Bull. Geol. Surv. Southern Rhodesia, 1935, no. 28, 47 pp., 1 map. Price 1*s.* 9*d.*

This mining area is like most others in Southern Rhodesia in that e modern workings are superimposed upon ancient native workings; at the reefs occur in a belt of the Basement Schists which is en- loped by granite; and that the reefs include both quartz veins and ritic impregnations. No unfamiliar features are disclosed in the port, and the area, which has produced some 70,000 ounces of gold ce 1909, is not considered to be of great promise. S. J. S.

NCOLN (Francis Church). *Mining districts and mineral resources of Nevada.* Reno (Nevada Newsletter Publishing Company), 1923, vi + 295 pp., 1 pl. (map). Price $3.00.

ODDARD (Carl). *Metal and nonmetal occurrences in Nevada.* Bull. Univ. Nevada (Bull. Nevada State Bureau of Mines and Mackay School of Mines), 1932, vol. 26, no. 6, 130 pp., 1 pl. (map). Price 50 cents.

These are useful compilations giving information of the location, story, geology, and bibliography of 336 mining districts arranged phabetically under counties. Alphabetical lists of ores and other onomic minerals with the localities of each are also given.

L. J. S.

Wahlstrom (Ernest E.). *The minerals of the White Raven mine, Ward, Colorado.* Amer. Min., 1935, vol. 20, pp. 377–383, 4 figs.

The fissure vein of lead-silver ore in pre-Cambrian granite with an associated dike of monzonite-porphyry resulted from the reopening and brecciation of an older vein of auriferous quartz-pyrite-chalcopyrite ore. The lead-silver vein contains quartz, manganiferous chalybite, baryte, galena, native silver, &c. The light greyish-brown manganiferous chalybite gave analyses :

	CO_2.	FeO.	MnO.	ZnO.	MgO.	CaO.	Insol.	Total.	Cleavage angle.
1.	38·95	40·37	18·62	0·42	1·26	1·17	—	100·79	73·1°
2.	38·40	38·11	22·85	0·80	0·02	0·55	—	100·73	73·0°
3.	37·63	42·69	16·95	0·50	0·10	0·05	2·94	100·86	—

L. J. S.

Landes (Kenneth K.). *Colorado pegmatites.* Amer. Min., 1935, vol. 20, pp. 319–333.

Detailed descriptions are given of the pegmatites and their minerals from several localities in the Pike's Peak region, Arkansas river valley, and Gunnison County. L. J. S.

Webb (Robert W.). *Tetradymite from Inyo mountains, California.* Amer. Min., 1935, vol. 20, pp. 399–400.

Myriads of minute brilliant tabular crystals of tetradymite are embedded with quartz, rutile, and chalcopyrite in earthy greenish bismutite from a quartz vein in monzonite in the Cerro Gordo district. L. J. S.

Barbosa (Octavio). *Resumo da geologia do Estado de Minas-Gerais.* Bol. Serv. Geol. Minas Gerais, 1934, no. 3, 40 pp., 1 table.

Guimarães (Djalma) & Barbosa (Octavio). *Mapa geologico do Estado de Minas Gerais.—Mappa geologico do Estado de Minas Geraes.* Ibid. 1934, no. 3. Single sheet 137 × 110 cm., scale 1 : 1,000,000. Price 3$000.

The explanation of the map gives an outline of the geology with mention of the rocks and economic minerals, and references to the literature. Pre-Cambrian rocks, rich in minerals, occupy the eastern and southern half of the State.

Quaternary—High-level gravels with gold and diamonds. Cave deposits.
Tertiary—Lake deposits, sand and clay, of limited distribution.
Cretaceous—Uberaba and Baurú Formations, sandstone, clay, limestone.

KASSIC—Basic and alkali igneous rocks, with Pt, Zr.
ASSIC—Sandstone, conglomerate, wind-worn pebbles; dolerite sills and basalt flows.
URIAN—Bambuhy Series, sandstone, limestone; Pb, Zn.
ONKIAN—Lavras Series—Conglomerate, sandstone, limestone; diamond.
Itacolumy Series—Conglomerate, quartzite, sandstone; diamond, rock-crystal.
Minas Series—Quartzite, slate, limestone; Au, Fe, Mn, Zn, Sb, bauxite, baryte, &c.
HAEAN—Gneiss, mica-schist, marble, &c.; pegmatite with tourmaline and beryl.

There are several variations in spelling in the text and on the p; e.g. Minas Geraes, Minas Gerais, Minas-Gerais; Itacolum colomy, Itacolomi. L. J. S.

ULIKOWSKI (K.). *Les roches éruptives des Andes de Bolivie. (Étude micrographique).* Arch. Min. Tow. Nauk. Warszaw. (Arch. Min. Soc. Sci. Varsovie), 1934, vol. 10, pp. 162–234, 2 pls., 5 text-figs.

LIKOWSKI (Kazimierz). *Skały magmowe Andów boliwijskich.* Ibid., pp. 235–242 (Polish summary).

ŁOWSKI (Roman). *Esquisse de la répartition des roches éruptives dans les Andes de Bolivie.* Ibid., pp. 122–161, 1 map, 2 pls., 5 text-figs. [Cf. M.A. **5**–167].

Descriptions are given of the geological occurrence and petrographical characters (with micrometric analyses) of a collection of ks from the mining districts in Bolivia. The Tertiary igneous ks are of the same magma type, ranging from tonalite-granodiorite-mellite in the Cordillera Real to dacite-rhyodacite-dellenite in the rdillera Oriental. Exceptional types are: a phonolite from Carayma, probably carboniferous; ankaratrite, picrite, and shoshonite alcime-banakite), which are probably Triassic. L. J. S.

SKÓLSKI (S.). *Les gisements argento-stannifères de Chocaya en Bolivie.* Avec un *Aperçu géologique* par Roman Kozłowski.—*Złoża srebrowo-cynowe Chocaya w Boliwji.* Arch. Min. Tow. Nauk. Warszaw. (Arch. Min. Soc. Sci. Varsovie), 1935, vol. 11, pp. 24–92 (French), pp. 93–102 (Polish summary), 6 pls., 3 text-figs.

Description of a collection of rocks and ores from Chocaya. The drothermal mineral veins are in a boss of propylitized dacite, with ne extensions into the surrounding Ordovician slates and associated

dacitic lavas and tuffs. The minerals include sericite, pyrite, cassiterite, quartz, abundant stannite, blende, wurtzite, tetrahedrite, pyrargyrite, &c. Franckeite was first found at this locality, and aramayoite [Min. Mag. **21**–156] and ramdohrite [M.A. **4**–341] have not been found elsewhere. L. J. S.

Hodge-Smith (T.). *Geological and mineralogical observations in Central Australia.* Rec. Australian Museum, 1932, vol. 18, pp. 415–442, 3 pls., 11 text-figs.

Account of an expedition from the Queensland border to Alice Springs. Several minerals were collected on the western margin of the pre-Cambrian plateau (Arunta complex) of gneisses, schists, granites, pegmatites, and quartz veins. At Jervois Range, with copper and lead ores, sphaerocobaltite and cobaltiferous pyrites were found. Muscovite and biotite as large crystals of good quality occur in the Hart Range in veins, with crystals of beryl, tourmaline, garnet, and apatite. Almandine crystals enclosed in mica are flattened on (211). Crystallographic measurements and chemical analyses are given for several of the minerals. L. J. S.

Hodge-Smith (T.). *Mineralogical Notes, no. V.* Rec. Australian Museum, 1934, vol. 19, pp. 165–176, 8 figs. [Cf. M.A. **4**–345.]

Stolzite, Broken Hill, New South Wales.—Colourless to pale grey crystals are of flat pyramidal *w*(117), or prismatic habit; new form *r*(441) [$a:c = 1:1{\cdot}5667$]. Vanadinite, Broken Hill.—Pale ruby-red crystals *c a b r x y u* [Dana's letters]. Iridosmine, Barraba, N.S.W.—Small flat grains, sp. gr. 18·02, with alluvial gold. Cassiterite, Storey's Creek, Ben Lomond district, Tasmania.—Twinned crystals showing ten forms. Purpurite, Euriowie Range, N.S.W.—Dark reddish-purple with marked pleochroism, occurring as a thin seam in lithia-pegmatite; a partial analysis on impure material agrees with $2(Fe,Mn)PO_4.H_2O$. Bismutite, Kingsgate, N.S.W.—Pale greenish yellow, pseudomorphous after molybdenite. L. J. S.

X-rays and Crystal-structure.

Machatschki (F.). *Kristallstruktur.* Handwörterbuch der Naturwissenschaften, Jena, 2nd edition, 1934, vol. 5, pp. 1262–1285, 25 figs.

A general review of the structure of crystals and the results obtained by X-ray methods. L. J. S.

MINOFF (G.) & BROOMÉ (B.). *Über Durchstrahlungsphotogramme an Einkristallen mit schnellen Elektronen und ihre Verwendbarkeit für Strukturbestimmungen.* Zeits. Krist., 1935, vol. 91, pp. 77–94, 20 figs.

Apparatus is described by means of which Laue photographs were ained by transmitted radiation. Difficulty was found in getting stalline plates sufficiently thin, but success was obtained with scovite, brucite, talc, graphite, orpiment, molybdenite, and walue- e by using cleavage flakes, and with gypsum, apophyllite, stibnite, nde, baryte, pyroaurite, and quartz by letting the rays pass through edge-shaped piece of the crystal very close to the edge. H. H.

MID (Erich). *Beschreibung einer neuen Lauekammer und des zugehörigen Reflexnetzes.* Zeits. Krist., 1935, vol. 91, pp. 95–96, 2 figs.

he time of exposure required for Laue photographs may be re- ced by letting the X-rays impinge at an angle of 45° on the al plate, the film being parallel to the incident ray. Diagrams given of the necessary apparatus and net for measuring.

H. H.

(R. E.). *A 5-kilowatt X-ray generator with a spinning target.* Proc. Physical Soc. London, 1934, vol. 46, pp. 703–712, 7 figs.

By rotating the water-cooled copper target of an X-ray tube ough three stages of vacuum stuffing) at a speed of 2,000 revolu- s per minute it is possible to run the tube continuously at 30,000 s, passing a current of 150 milliamperes. An intense beam of ays suitable for crystallographic work is then produced.

F. A. B.

ZKIEWICZ (Antoni). *Über die Zylinder-Laueaufnahmen.—Cylindryczne zdjęcia Lauego.* Arch. Min. Tow. Nauk. Warszaw. (Arch. Min. Soc. Sci. Varsovie), 1935, vol. 11, pp. 103–108 (Germ.), pp. 110–112 (Polish), 1 pl., 3 text-figs.

n all-round Laue photograph is obtained by using a cylindrical era [cf. L. Chrobak, M.A. **5**–173; V. Goldschmidt, M.A. **5**–461]. k-salt and syngenite are given as examples of the method.

L. J. S.

Barnes (W. H.) & Wendling (A. V.). *An X-ray method of distinguishing between certain space-groups in the hexagonal system.* Trans. Roy. Soc. Canada, 1933, ser. 3, vol. 27, sect. 3, pp. 133–140, 4 figs.

—— —— *Note on the Laue symmetry exhibited by orthogonal crystals.* Amer. Min., 1935, vol. 20, pp. 253–259, 3 figs.

Discusses the Laue patterns which may be identical for certain different classes of symmetry. L. J. S.

Meisel (Karl). *Vorschläge zur einfachen Reproduktion und Beurteilung von Debye-Aufnahmen.* Zeits. Krist., 1935, vol. 90, pp. 92–95, 2 figs.

By the photographic reproduction of a powder photograph of a substance using a linear and wedge-slit system the original lines on the negative are changed into a system of peaks of different height. A comparison of this picture with a photometer record shows that the relative heights of the peaks are a fairly accurate measure of relative intensities. The method is suitable for exact identification of a substance by powder photographs. F. A. B.

Bradley (A. J.). *The absorption factor for the powder and rotating crystal methods of X-ray crystal analysis.* Proc. Physical Soc. London, 1935, vol. 47, pp. 879–899, 9 figs.

Tabulated data are given for calculating X-ray absorption-factors for all values of linear absorption-factor and radius of specimen. These data can be used for the correction of intensities of lines on powder photographs and equatorial spots of rotation photographs providing temperature corrections be also applied. F. A. B.

Hettich (A.). *Erschließung der absoluten Röntgen-Intensitäten mit Hilfe anderer physikalischer Daten.* Zeits. Krist., 1935, vol. 91, pp. 154–156.

A mathematical expression for the absolute intensity of X-ray diffraction from a crystal plane is deduced, not involving under certain conditions intensity measurements. F. A. B.

Seljakow (N.). *Über eine neue Eigenschaft der Strukturanalyse.* Zeits. Physik, 1934, vol. 92, pp. 543–546, 4 figs.

It is shown by a stereographic projection that the high-angle X-ray diffractions from a crystal are the most sensitive to a small change in orientation. The method is suggested for a study of the relative orientation of neighbouring lamellae of the Widmanstätten structure. [M.A. **6**–36]. F. A. B.

AS (W.) & EKSTEIN (H.). *Über die Bestimmung der Krümmungsachse gebogener Kristalle aus Lauediagrammen.* Zeits. Krist., 1935, vol. 90, pp. 408–414, 4 figs.

Formulae are given for determining the position of the axis of rvature of a distorted crystal by measurement of the displacement he spots of a Laue diagram. As an illustration is taken the case zinc wire. H. H.

ES (F.) & NIEWENKAMP (W.). *Interferenzerscheinungen an zweidimensionalen Kristallen.* Zeits. Krist., 1935, vol. 90, pp. 273–278, 6 figs.

he authors discuss the theory of interference phenomena observable n two-dimensional crystals are investigated by the rotation hod under monochromatic or polychromatic X-rays. H. H.

ES (Fritz). *Zweidimensionale Überstrukturen.* Zeits. Krist., 1935, vol. 90, pp. 279–282, 5 figs.

he theory of the previous paper is illustrated by photographs of ucherite (Ni_3As_2). H. H.

TICH (Alfred). *Beiträge zur Methodik der Strukturbestimmung.* Zeits. Krist., 1935, vol. 90, pp. 473–492, 10 figs.

mong several suggested improvements in crystal-structure nique are considered the indexing of Weissenberg photographs and adjustment of crystals with the X-ray goniometer. A method lso given for calculating the contribution of an atomic group of stant shape and dimensions to the structure factor. F. A. B.

ALD (P. P.). *Bemerkungen zur vorstehenden Arbeit von A. Hettich Abschnitt IV, „Eigendiagramme" von Atomgruppen.* Zeits. Krist., 1935, vol. 90, pp. 493–494.

criticism of the method advocated by Hettich for dealing with contribution of atomic groups to structure factors. F. A. B.

RGER (M. J.). *The Weissenberg reciprocal lattice projection and the technique of interpreting Weissenberg photographs.* Zeits. Krist., 1934, vol. 88, pp. 356–380, 7 figs. Corrections, ibid., 1935, vol. 90, p. 563.

method of indexing Weissenberg photographs by constructing procal lattice line curves. The data and charts necessary for this cedure are given, and attention is drawn to the advantages of

inclining the X-ray beam to the rotation axis at an angle equal to the cone-angle of the layer-line on the film. A simple way of modifying existing Weissenberg cameras for the equi-inclination method is described. F. A. B.

Crowfoot (D.). *The interpretation of Weissenberg photographs in relation to crystal symmetry.* Zeits. Krist., 1935, vol. 90, pp. 215–236, 14 figs.

An extension of Buerger's treatment concerning the relation of crystal-symmetry to the arrangement and intensities of the spots on Weissenberg photographs. The special cases of layer-line photographs of anorthic and of monoclinic crystals rotated about the *a* or *c* axes are considered in detail. A system is developed by which the point-group symmetry of a crystal may be deduced from equatorial and layer-line Weissenberg photographs taken about a single rotation axis. F. A. B.

Ekstein (H.) & Fahrenhorst (W.). *Eine einfache Bestimmung der räumlichen Orientierung von Kristallen.* Zeits. Krist., 1934, vol. 89, pp. 525–528, 3 figs.

If the lattice dimensions of a substance are known, the position of the crystallographic axes in a crystal without faces can be obtained from stereographic projections of a rotation photograph and a Laue photograph, the latter taken along any direction perpendicular to the axis of rotation. F. A. B.

Schdanow (H. S.). *Bestimmung der Kornzahl im Bereiche von 1 bis 100 μ auf Grund der Debye-Scherrer-Aufnahmen.* Zeits. Krist., 1935, vol. 90, pp. 82–91, 10 figs.

The number of crystalline particles per unit volume in a powder or metal can be determined from observations of the number of interference spots on the Debye-Scherrer rings. Application of the theory was made to determine the increase or decrease of the number of copper particles during recrystallization. H. H.

Lotmar (W.). *Zum Aufbau der Schichtengitter.* Zeits. Krist., 1935, vol. 91, pp. 187–191, 3 figs.

In Röntgen photographs of graphite, halloysite, &c., the (*hkl*) lines are absent or diffuse, while the (*hk*0) and (00*l*) lines are comparatively sharp. The phenomenon is explained by assuming an appropriate deformation of the lattice. H. H.

EHLINGER (U.). *Die Ursachen der Linienverbreiterung bei Pulver- und Dreh-Kristallaufnahmen mit Röntgenstrahlen.* Zeits. Metallkunde, Berlin, 1931, vol. 23, pp. 147–149, 7 figs.

A study of powder and rotation photographs of samples of various ld-worked metals shows that broadening of the diffraction lines ay be caused by differences in composition of constituent grains 5·10^{-5} cm. The broadening of diffraction lines for samples of erage grain-size $< 5 \cdot 10^{-5}$ cm. may result not only from the small ain-size but also from changes of composition and conditions of rain with periodicities corresponding to 10 to 100 Å. F. A. B.

ALDO (Allen W.). *Identification of the copper ore minerals by means of X-ray powder diffraction patterns.* Amer. Min., 1935, vol. 20, pp. 575–597, 1 pl., 1 text-fig.

Fifty-one copper minerals are arranged in order of magnitude of first line readings and in order of the intensities of the lines in e powder photographs. L. J. S.

ESSELOWSKI (W. S.) & WASSILIEW (K. W.). *Röntgenographische Untersuchung der dispersen Strukturen verschiedener Graphitarten.* Zeits. Krist., 1934, vol. 89, pp. 156–174, 5 figs. [Cf. M.A. **6**–89.]

An X-ray study of various natural and artificial graphites and aphite-bearing substances upon which is based a classification cording to graphite content, particle size, crystal-form of crystal- es, and orientation. F. A. B.

VEN (E. A.), PICKUP (Llewelyn), & ROBERTS (I. O.). *Lattice constants of five elements possessing hexagonal structure.* Zeits. Krist., 1935, vol. 91, pp. 70–76, 1 fig.

For zinc, magnesium, ruthenium, osmium, and beryllium hexagonal ructures were found having respectively a 2·6591, 3·2020, 2·6987, 7304, 2·2812 Å., and c 1·8560, 1·6240, 1·5833, 1·5785, 1·5685 Å. ±0·0005 in each case), with calculated densities at 18° C. 7·135, 737, 12·45, 22·61, 1·845. H. H.

AVAL (Jean). *Diffraction des rayons X par l'atome d'argent (facteur de structure).* Compt. Rend. Acad. Sci. Paris, 1935, vol. 200, pp. 1605–1607.

The scattering power of silver powder at $15 \pm 3°$ has been deter- ined for monochromatic radiation, $K\alpha + K\alpha'$ (0·7078 + 0·7121 Å.), tained by reflecting Mo radiation from (100) of sodium chloride.

The F values so determined are higher than those obtained by Chrobak [M.A. **5**–309], e.g. (111) $34{\cdot}6_0$, (200) $19{\cdot}9_4$, (220) $12{\cdot}9_0$, (311) $23{\cdot}7_6$, and (222) $28{\cdot}8_0$. The mass coefficient of absorption, μ, is 26·5. C. A. S.

Ehrenberg (W.). *Atomfaktorbestimmung an metallischen Beryllium.* Zeits. Krist., 1934, vol. 89, pp. 185–188, 1 fig.

The atomic scattering factor of beryllium was determined by ionization spectrometer measurements on a powdered specimen of the highly purified metal. The measurements confirm Hartree's calculated value and are in closer agreement with the theoretical value for the beryllium atom than the beryllium ion. F. A. B.

Clark (George L.) & Beckwith (M. M.). *A method for detection and evaluation of residual distortion in crystals with special reference to electric steel.* Zeits. Krist., 1935, vol. 90, pp. 392–398, 5 figs.

The peripheral widening of diffraction spots on monochromatic X-ray photographs of stationary samples of silicon-steel subjected to various degrees of cold working and annealing is a measure of residual strain. Specimens with low residual grain distortion possess high magnetic permeability, but the relation between residual distortion and magnetic properties is complex. F. A. B.

Post (Carl B.). *An analytical method for determining the preferred orientations of crystals in mechanically worked cubic metals.* Zeits. Krist., 1935, vol. 90, pp. 330–340, 2 figs.

An extension of earlier X-ray methods of determination of preferred orientation in rolled sheets of cubic metals. The procedure is illustrated in detail by evaluating data for rolled silver sheets.

F. A. B.

Hume-Rothery (William) & Powell (Herbert M.). *On the theory of super-lattice structures in alloys.* Zeits. Krist., 1935, vol. 91, pp. 23–47, 14 figs.

In many metallic alloys atomic re-arrangement occurs on slow cooling or annealing at a low temperature. The authors call the new structure a 'normal metallic superlattice' when the arrangement would be very close to that of the original solid solution, if the distinction between the atoms were ignored; an 'interaction superlattice' when the alloy has abnormal properties though structurally similar to a normal superlattice; and an 'interaction structure'

hen the change is more complete. They assume that: (1) the rmation of a normal superlattice takes place so that the solute oms occupy the highest zone possible relative to one another; ?) the relative stability of a superlattice decreases rapidly as its zone umber increases; (3) the tendency for a solid solution to form a uperlattice becomes greater with increasing difference between the omic diameters of the solvent and solute atoms; (4) where alterna- ve arrangements are possible the most stable structure is that for hich the solute atoms as a whole have the fewest solute neighbours the lowest zone. These hypotheses are tested on Fe_2Al, FeAl, Au_3Au, CuAu alloys. H. H.

EGARD (Ch.). *Constitution et structure des alliages d'argent et de calcium.* Zeits. Krist., 1935, vol. 90, pp. 399–407, 1 fig.

The only alloys of silver and calcium which have a definite mole- lar structure are AgCa with a cubic face-centred cell having an ge of 9·07 Å., and Ag_3Ca, which is tetragonal with $c/a = 0{\cdot}88$. H. H.

LRRIAANSE (T.). *The crystal structure of Au_2Bi.* Zeits. Krist., 1935, vol. 90, pp. 322–329, 3 figs.

The space-group of the alloy Au_2Bi is O_h^7. The unit cell contains ght molecules and has an edge of 7·942 Å. H. H.

EIPEL (Evald von). *The lattice-constant of galena determined with a new X-ray spectrometer.* Arkiv Mat. Astron. Fysik, Stockholm, 1935, vol. 25 A., no. 8, 18 pp., 9 figs.

Cleavage fragments of galena from Příbram, Bohemia, were selected ptically for exact measurement of the unit-cell edge by an improved -ray spectrometer, and gave *a* $5{\cdot}923_{34}$ Å. F. A. B.

UERGER (M. J.). *The unit cell and space group of realgar.* Amer. Min., 1935, vol. 20, pp. 36–43, 1 fig.

With a new orientation [$x(\bar{1}01)$ is taken as $c(001)$] the unit cell of ealgar has dimensions *a* 9·27, *b* 13·50, *c* 6·56 Å. ($a:b:c = 0{\cdot}6878:1:$ ·4858), β 73° 27′, and contains 16 AsS. The space-group is C_{2h}^5, but ie structure cannot be completely determined. L. J. S.

CHNAASE (Horst). *Kristallstruktur der Manganosulfide und ihrer Mischkristalle mit Zinksulfid und Cadmiumsulfid.* Zeits. Physikal. Chem., Abt. B., 1933, vol. 20, pp. 89–117.

MnS precipitated from solution under various conditions is of

different forms. (1) Green α-MnS, identical with alabandine, has the rock-salt structure with a 5·212 Å. and 4 mols. in the unit cell; d 4·056. (2) Red β-cubic MnS has the zinc-blende structure with a 5·600 Å. and 4 mols. in the cell; d 3·289. (3) Red β-hexagonal MnS has the wurtzite structure with a 3·976, c 6·432 Å., and 2 mols. in the cell; d 3·280. The modifications (2) and (3) are metastable and are transformed into (1) by heating at 200–300° C. MnS–CdS gives a continuous series of mixed crystals in the modifications (2) and (3), whilst MnS–ZnS (cf. erythrozincite) shows a gap. In some of the precipitates MnS_2 is also present; this has the pyrite structure with a 6·10 Å. L. J. S.

Fylking (K. E.). *Phosphides and arsenides with modified nickel-arsenide structure.* Arkiv Kemi, Min. Geol. Stockholm, 1935, vol. 11 B, no. 48, 6 pp. 1 fig.

The crystal-structure of artificial manganese phosphide MnP has been worked out in detail from Laue and rotation photographs. It is based upon an orthorhombic lattice closely related to the hexagonal nickel arsenide NiAs structure and is built up of crossed chains of manganese and phosphorus atoms. Powder photographs of artificial phosphides and arsenides of the MnP type show that they possess the same crystal-structure with different lattice dimensions.

	a.	*b*.	*c*.
MnP	5·905 Å	5·249 Å	3·167 Å.
FeP	5·782	5·177	3·089
CoP	5·588	5·066	3·274
MnAs	6·38	5·63	3·62
FeAs	6·016	5·428	3·366
CoAs	5·96	5·15	3·51

F. A. B.

Tunell (G.) & Ksanda (C. J.). *The crystal structure of calaverite.* Journ. Washington Acad. Sci., 1935, vol. 25, pp. 32–33.

X-ray photographs of calaverite from Cripple Creek, Colorado, give a unit cell of dimensions a 7·18, b 4·40, c 5·07 Å., β 90° ± 30′, containing two molecules of $AuTe_2$. The crystal is monoclinic with space-group C_{2h}^3, C_2^3, or C_s^3 [Cf. M.A. **5**–205.] L. J. S.

Kôzu (Shukusuké) & Takané (Katsutoshi). *The crystal structure of chalcopyrite.* Proc. Imp. Acad. Tokyo, 1934, vol. 10, pp. 498–501, 1 fig.

Rods cut parallel to [001] and [110] from crystals of chalcopyrite

m Arakawa mine, Ugo, Japan, gave a 5·28, c 5·22, (c/a 0·989) with mols. $CuFeS_2$ in the unit cell. The space-group is V_d^5, tetragonal-henoidal class. [Cf. M.A, **2**–203, 332 ; **5**–175.] L. J. S.

ßNER (B.) & KRAUS (O.). *Über Kristallform und chemische Zusammensetzung von Polybasit.* Centr. Min., Abt. A, 1934, pp. 1–6.

A thick-tabular crystal of polybasite from Guanaxuato gave a gonal Lauegram, a 7·50, c 11·95 Å., whilst a thin flake from Freig gave a 15·04, c 12·03 Å. Under the microscope the latter shows ns of lamellar twinning. An orthorhombic (or monoclinic with 0°) cell, a 12·99, b 7·50, c 11·95 Å., contains two mols. $8(Ag,Cu)_2S.$ $_2S_3$. L. J. S.

NNINGER (M.). *Studien über die Röntgenreflexion an Steinsalz und den Realbau von Steinsalz.* Zeits. Krist., 1934, vol. 89, pp. 344–374, 8 figs.

A cleavage surface of artificial rock-salt specially prepared yields ery narrow sweep curve and the observed intensity of X-ray reion is in close agreement with the theoretical value for the ideally fect crystal. After polishing, the intensity increases to the value nd by previous workers close to the theoretical value for the ally imperfect crystal. F. A. B.

ARREN (B. E.) & HILL (C. F.). *The structure of vitreous BeF_2.* Zeits. Krist., 1934, vol. 89, pp. 481–486, 3 figs.

An X-ray photograph of a thin chip of artificial beryllium fluoride ss was obtained using Cu-K_α radiation made strictly monochroic by reflexion from rock-salt and evacuating the camera during posure to avoid scattering of the X-rays by air. The diffraction ensity distribution of the photograph agrees closely with the disbution calculated on the random network hypothesis. SiO_2, GeO_2, d BeF_2 glasses are shown to have the same kind of tetrahedral ucture. 'It makes but little difference whether one refers to glass an amorphous solid or an undercooled liquid, since the two terms an the same thing.' F. A. B.

VER (A. K. van) & NIEUWENKAMP (W.). *Die Kristallstruktur von Calciumchlorid, $CaCl_2$.* Zeits. Krist., 1935, vol. 90, pp. 374–376.

The space-group of calcium chloride is V_h^{12}. The unit cell contains o molecules of $CaCl_2$ and has a 6·24, b 6·43, c 4·20 Å. H. H.

Ketelaar (J. A. A.). *Die Kristallstruktur der Aluminiumhalogenide II. Die Kristallstruktur von $AlCl_3$.* Zeits. Krist., 1935, vol. 90, pp. 237–255, 6 figs.

Aluminium chloride has the space-group C_2^3. The unit cell contains four molecules of Al_2Cl_6 and has a 5·91, b 10·24, c 6·16 Å., β 71° 21′. The substance is pseudo-hexagonal. H. H.

Wooster (Nora). *The crystal structure of $AlCl_3$.* Zeits. Krist., 1935, vol. 90, p. 562.

The yellow modification of $AlCl_3$ is trigonal and isomorphous with $CrCl_3$. The white modification is probably triclinic and pseudo-trigonal. H. H.

Mooney (R. C. L.). *The configuration of the triiodide group in ammonium triiodide crystals.* Zeits. Krist., 1935, vol. 90, pp. 143–150, 1 fig.

Ammonium tri-iodide has the space-group V_h^{16}. The unit cell contains four molecules of NH_4I_3 and has a 6·64, b 9·66, c 10·82 Å. The tri-iodide group is linear with spacings of 2·82 and 3·10 Å. between the atoms. H. H.

Feitknecht (W.) & Lotmar (W.). *Die Struktur des grünen basischen Kobaltbromids.* Zeits. Krist., 1935, vol. 91, pp. 136–141.

The unit cell of $Co_5(OH)_9Br$ has a 3·13, c 24·7 Å. The structure is to some extent irregular, being similar in this respect to that of cobalt chloride and other isomorphous salts. H. H.

Theilacker (Walter). *Die Kristallstruktur der Guanidoniumhalogenide. II. Über den Kristallbau des Guanidoniumjodids $C(NH_2)_3J$.* Zeits. Krist., 1935, vol. 90, pp. 51–76, 7 figs.

Guanidonium iodide has the space-group C_{6v}^4. Its unit cell contains four molecules of $C(NH_2)_3I$ and has a 7·19, c 12·30 Å. H. H.

Theilacker (Walter). *Die Kristallstruktur der Guanidoniumhalogenide. III. Über den Kristallbau des Guanidoniumbromids $C(NH_2)_3Br$.* Zeits. Krist., 1935, vol. 90, pp. 256–272, 3 figs.

Guanidonium bromide has the space-group V_h^{16}. The unit cell contains four molecules of $C(NH_2)_3Br$ and has a 6·77, b 8·64, c 8·30 Å. H. H.

GEL (Gerhard). *Die Kristallstrukturen einiger Hexachlorokomplexsalze.* Zeits. Krist., 1935, vol. 90, pp. 341–373, 3 figs.

The salts have the space-group O_h^5. The unit cell contains four blecules. There are four tetravalent atoms at (000), eight monodent atoms or groups at $(\frac{1}{4}\frac{1}{4}\frac{1}{4})$, twenty-four chlorine atoms at $(m00)$, ere $m = 0{\cdot}230 - 0{\cdot}250$.

	a.		a.		a.
$_2TiCl_6$	9·922 Å.	$(NH_4)_2SeCl_6$	9·935 Å.	K_2PtCl_6	9·725 Å.
$TiCl_6$	10·219	Rb_2SeCl_6	9·978	$(NH_4)_2PtCl_6$	9·843
$_2ZrCl_6$	10·178	Cs_2SeCl_6	10·260	Rb_2PtCl_6	9·885
$ZrCl_6$	10·407	K_2TeCl_6	10·143	Cs_2PtCl_6	10·192
$SnCl_6$	9·983	$(NH_4)_2TeCl_6$	10·178	Tl_2PtCl_6	9·755
$H_4)_2SnCl_6$	10·038	Rb_2TeCl_6	10·233	$(NH_4)_2PbCl_6$	10·135
$_2SnCl_6$	10·099	Cs_2TeCl_6	10·445	Rb_2PbCl_6	10·195
$SnCl_6$	10·347	Tl_2TeCl_6	10·107	Cs_2PbCl_6	10·416
$SnCl_6$	9·970				

H. H.

X (E. G.) & WEBSTER (K. C.). *The structure of trimethyl platinic chloride* $(CH_3)_3PtCl$. Zeits. Krist., 1935, vol. 90, pp. 561–562.

Trimethyl platinic chloride has a body-centred cubic unit cell with ge of 10·52 Å., containing eight molecules of $(CH_3)_3PtCl$. The ace-group is one of T^3, T^5, T_d^3. H. H.

ST (C. D.). *Crystal structure of* $Rh(NH_3)_5Cl)Cl_2$. Zeits. Krist., 1935, vol. 91, pp. 181–186, 1 fig.

The space-group of the pentammine is V_h^{16}. The unit cell contains r molecules of $(Rh(NH_3)_5Cl)Cl_2$ and has a 13 32, b 6·71, c 10·42 Å. H. H.

ST (C. D.). *Diffraction of X-rays by a linear crystal grating of AgCN.* Zeits. Krist., 1935, vol. 90, pp. 555–558, 2 figs.

Monochromatic X-ray photographs of twin crystals of silver anide AgCN crystallized from ammoniacal solution show uniformly ackened hyperbolae superposed upon a weak Laue spot-pattern. e hyperbolae are a linear crystal grating diffraction effect due to ndom translations of individual rigid Ag–C–N–Ag chains from ints of the space-lattice. F. A. B.

ÉRARD (J.) & RASSENFOSSE (A. de). *Etude cristallographique du palladocyanure de baryum.* Zeits. Krist., 1935, vol. 90, pp. 470–471.

Pallado-cyanide of barium has the space-group C_{2h}^6. The unit cell ntains four molecules of $BaPd(CN)_4.4H_2O$ and has a 11·95, b 13·82, ·71 Å., β 76° 22′. The salt is isomorphous with $BaPt(CN)_4.4H_2O$ d $BaNi(CN)_4.4H_2O$. H. H.

Nieuwenkamp (W.). *Zweidimensionale Cristobalitkristalle.* Zeits. Krist., 1935, vol. 90, pp. 377–380, 7 figs.

Cristobalite is of three kinds. The regular octahedra have a tetragonal cell with a 7·3, c 6·9 Å. The six-sided plates have two-dimensional lattices parallel to (111). The third type consists of pseudomorphs after tridymite. H. H.

Tunell (G.), Posnjak (E.), & Ksanda (C. J.). *Geometrical and optical properties, and crystal structure of tenorite.* Zeits. Krist., 1935, vol. 90, pp. 120–142, 4 figs.

Goniometric and optical measurements and a study of the cleavage point to a monoclinic structure for tenorite (melaconite). Also X-ray photographs point to a space-group C_{2h}^6 with a unit cell containing four molecules of CuO and having a 4·653, b 3·410, c 5·108 Å., β 80° 31′. H. H.

Inuzuka (Hideo). *The crystal structure of tellurite (TeO_2).* Journ. Geol. Soc. Tokyo, 1934, vol. 41, pp. 131–138 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 11.

From previous data [M.A. **6**–43] the positions of the atoms are fixed. L. J. S.

Schoep (A.) & Billiet (V.). *Note sur le réseau de l'uraninite.* Bull. Soc. Géol. Belgique, 1935, vol. 58, pp. B 198–B 206, 1 fig.

Cubic crystals of uraninite from Kasolo, massive uraninite associated with linnaeite from Shinkolobwe, and UO_2 obtained by dehydration and reduction of becquerelite all give by X-ray methods a unit cell of edge a 5·47 Å. [Cf. M.A. **6**–96.] L. J. S.

Finch (G. I.) & Wilman (H.). *The lattice dimensions of zinc oxide.* Journ. Chem. Soc. London, 1934, pp. 751–754, 1 pl.

Zinc oxide smoke, obtained by burning zinc in oxygen, was deposited on gold leaf (the dimension, a 4·0700, of which was used as a standard for comparison). From the electron diffraction patterns the values obtained for the zinc oxide are a 3·258, c 5·239 Å. (c/a 1·607). These differ somewhat from the values obtained by the X-ray method. [Cf. M.A. **1**–313; **2**–14, 203, 329; **5**–257; **6**–57.] L. J. S.

Bunn (C. W.). *The lattice-dimensions of zinc oxide.* Proc. Physical Soc. London, 1935, vol. 47, pp. 835–842.

Using the precision X-ray powder method devised by Bradley and

y [M.A. **5**–305], the unit-cell dimensions of zinc oxide smoke are 3·2426, *c* 5·1948 Å. These differ from the values (*a* 3·258, *c* 5·239 Å.) tained by the electron diffraction method. The difference in axial rios (*c*/*a* 1·606 and 1·607 respectively), which is independent of e lattice-dimensions of the reference substance used in electron ffraction work, indicates a change of axial ratio at the surface of e material. F. A. B.

ERWEY (E. J. W.). *The crystal structure of* γ-Fe_2O_3 *and* γ-Al_2O_3. Zeits. Krist., 1935, vol. 91, pp. 65–69, 2 figs.

Artificial preparations of γ-Fe_2O_3 and γ-Al_2O_3 give powder photo- hs nearly identical with those of magnetite and spinel respec- ely. Thewlis [M.A. **5**–178] has suggested that the structure of Fe_2O_3 is given by a spinel unit cell with four additional oxygen oms, i.e. 36 in all. The assumption of such a structure of γ-Al_2O_3 ds to a calculated figure for the density 4·1, considerably above e observed figure 3·42. The author gives evidence showing that oxygen arrangement is the same as in normal spinels, i.e. 32 ygen ions per unit cell. The $2\frac{2}{3}$ cation positions left vacant in Al_2O_3 and γ-Fe_2O_3 are distributed statistically over the 24 cation sitions. F. A. B.

WING (F. J.). *The crystal structure of diaspore.* Journ. Chem. Physics (Amer. Inst. Physics), 1935, vol. 3, pp. 203–207, 2 figs.

Laue and oscillation photographs gave a unit cell of dimensions 4·40, *b* 9·39, *c* 2·84 Å. containing $4AlHO_2$; space-group V_h^{16}. The ucture is discussed from the standpoint of the co-ordination theory. ydrogen bonds are established, and the formula may be written $(AlHO_2)_n$ or $(HAlO_2)_n$; but not as $Al_2O_3.H_2O$, $Al_2O_2(OH)_2$, or $AlO(OH)$, ere being no water or (OH) ions. The possible existence of a second odification corresponding with lepidocrocite is considered.

L. J. S.

WING (F. J.). *The crystal structure of lepidocrocite.* Journ. Chem. Physics (Amer. Inst. Physics), 1935, vol. 3, pp. 421–424, 1 fig.

Lepidocrocite from Eiserfeld, Westphalia, gave a unit cell of mensions *a* 3·87, *b* 12·51, *c* 3·06 Å., containing 4 mols. of FeO(OH); ace-group V_h^{17}. The structure consists of iron-centred oxygen tahedra joined by sharing edges into layers, the layers being held gether by hydrogen bonds. The relation between the diaspore-

goethite and boehmite-lepidocrocite structures is discussed. [Cf. M.A. **5**–179.] L. J. S.

Megaw (H. D.). *Structure of crystalline zinc hyroxide $Zn(OH)_2$.* Zeits. Krist., 1935, vol. 90, pp. 283–284.

The crystals of $Zn(OH)_2$ investigated by Corey and Wyckoff (Zeits. Krist., 1933, vol. 86, p. 8) have the same structure as those prepared by Fricke and measured by Gottfried and Mark (Zeits. Krist., 1927, vol. 65, p. 416). The discrepancy in the results published by the two pairs of authors is due to a mistake in the orientation of the crystals by Gottfried and Mark. H. H.

Goldsztaub (Stanislas). *Étude de quelques dérivés de l'oxyde ferrique (FeO.OH, FeO^2Na, FeOCl); détermination de leurs structures.* Bull. Soc. Franç. Min., 1935, vol. 58, pp. 6–76, 19 figs. Thèse Univ. Paris, 1934, 77 pp., 19 figs.

A detailed account of X-ray, thermal, and magnetic measurements previously published. [M.A. **5**–179, 313, 469.] F. A. B.

Garrido (Jules). *Structure cristalline de la manganite.* Compt. Rend. Acad. Sci. Paris, 1935, vol. 200, pp. 69–71, 1 fig.

Garrido (J.). *Structure de la manganite.* Bull. Soc. Franç. Min., 1935, vol. 58, pp. 224–241, 5 figs. [Cf. M.A. **5**–25.]

X-ray examination shows that the two apparently optically different varieties of manganite have the same structure, with a unit cell with a 8·84, b 5·23, c 5·74 Å., containing 8MnO(OH), but divisible into four with a 3·42, b 5·23, c 2·87 Å. [cf. M.A. **5**–25], space-group $Pnnm$ (D_{2h}^{12}). The oxygen atoms are nearly close packed, thus resembling diaspore and goethite [cf. M.A. **5**–313], but the Mn atoms are placed so as to be octahedrally surrounded by oxygen with Mn–O = 1·97 Å., and co-ordination number 6. Oxygen cannot be distinguished from OH without more detailed examination.

C. A. S.

Barth (Tom. F. W.). *Non-silicates with cristobalite-like structure.* Journ. Chem. Physics, 1935, vol. 3, pp. 323–325, 2 figs.

The compounds $K_2O.Al_2O_3$ [M.A. **6**–56] and $K_2O.Fe_2O_3$, and also α-carnegieite ($NaAlSiO_4$) and Na_2CaSiO_4 [M.A. **5**–185], have the same structure as high-cristobalite [M.A. **5**–177]. Al–O chains take the place of Si–O chains, and potassium, &c., atoms are situated in the interspaces. L. J. S.

LBY (M. Y.) & LACOSTE (L. J. B.). *The crystal structure of witherite.* Zeits. Krist., 1935, vol. 90, pp. 1–7, 1 fig.

Witherite has a structure similar to those of aragonite, potassium rate, and cerussite. The space-group is V_h^{16}. The unit cell tains four molecules of $BaCO_3$ and has a 5·28, b 8·83, c 6·39 Å.

H. H.

YLOR (W. H.), DARBYSHIRE (J. A.), & STRUNZ (H.). *An X-ray investigation of the felspars.* Zeits. Krist., 1934, vol. 87, pp. 464–498, 7 figs.

Unit-cell dimensions and specific gravities of crystals and cleavage es of the following felspars have been determined:

	a	b	c	d
Sanidine	8·45	12·90	7·15 Å	2·57
Adularia	8·45	12·90	7·15	2·569
Hyalophane	8·52	12·95	7·14	2·782
Celsian	8·13	13·10	7·29	3·37
Albite	8·14	12·86	7·17	2·619
Andesine	8·14	12·86	7·17	2·667
Labradorite	8·21	12·95	14·16	2·698
Anorthite	8·21	12·95	14·16	2·760

ical data and localities are also given, but the values of the inter- al angles α, β, and γ are assumed from goniometric measurements previous workers. X-ray work supports the view that orthoclase celsian are end-members of an isomorphous series with hyalo- ne as an intermediate member. As the barium content increases re is a random replacement of potassium ions K^+ by barium ions $^{++}$ in the crystal-structure of sanidine with an equivalent replace- nt of silicon by aluminium. No X-ray diffractions were detected ch suggest a doubling of the c-axis of celsian. Laue photographs albite show that (010) is no longer a plane of symmetry as in idine, and corresponding spots on rotation photographs of the two erals show small differences in intensity. The principal difference he crystal-structure is a slight closing-up of the chains of four- s parallel to the a-axis, resulting in a different oxygen atom ironment of the sodium ions to that of the potassium ions in idine. The replacement of sodium by smaller calcium ions in the gioclase felspars results in a further tilting of the chains of four- s and further departure from monoclinic symmetry. X-ray k indicates a doubling of the c-axis at a composition correspond- to equal numbers of sodium and calcium atoms. The plagio- es should therefore be regarded as a double isomorphous series

from Na_2 to NaCa and from NaCa to Ca_2. Examination of perthitic felspars suggests that the tetrahedron framework may be continuous throughout the lamellar crystal but with regions of greater and lesser extension of the chains which appear optically as orthoclase and albite lamellae respectively. The (010) and (001) cleavages of felspar correspond to breaking bonds between adjacent chains of four-rings; any other cleavage would break bonds within the four-rings themselves. The proposed crystal-structures also account in detail for the albite, pericline, Manebach, and Baveno twin-laws and explain the observed parallel growth of quartz on felspar. Optical examination is much more sensitive than X-ray examination to a change in symmetry and to small distorting forces. Neither optical nor X-ray evidence supports Mallard's theory that all felspars are anorthic and that adularia, sanidine, and hyalophane are only pseudo-monoclinic by twinning. F. A. B.

Itô (Teiichi). *The problem of the rhombic pyroxenes.* Journ. Geol. Soc. Tokyo, 1934, vol. 41, pp. 604–627 (Japanese); abstract in Japanese Journ. Geol. Geogr., 1935, vol. 12, abstracts p. 12.

Ito (T.). *On the symmetry of the rhombic pyroxenes.* Zeits. Krist., 1935, vol. 90, pp. 151–162.

The author discusses and repeats the work done by Warren and Modell [M.A. **4**–366] on the relation between the structures of diopside and enstatite. He considers the possibility of explaining these structures by twinning repeated at intervals comparable with the dimensions of the unit cell, though not within the cell itself. H. H.

Kołaczkowska (Marja). *Struktura sodalitu.—La structure de la sodalite.* Arch. Min. Tow. Nauk. Warszaw. (Arch. Min. Soc. Sci. Varsovie), 1935, vol. 11, pp. 150–169 (Polish), pp. 170–174 (French résumé), 2 pls., 8 text-figs.

A crystal of sodalite from Mt. Vesuvius, Italy, gives by the rotation method a cubic unit cell a 8·933 Å. containing $3Na_2Al_2Si_3O_8 \cdot 2NaCl$; space-group T_d^3. A crystal-structure based upon Goldschmidt's values of interatomic distances is figured and described. F. A. B.

Brandenberger (E.). *Röntgenographische Charakteristik der verschiedenen Modifikationen des Dicalciumsilikats, Ca_2SiO_4.* Schweiz. Min. Petr. Mitt., 1934, vol. 14, pp. 473–477, 1 fig.

Lines are given for three distinct modifications, α, β, and γ. L. J. S.

ALDBAUER (Louis) & McCANN (D. C.). *Crystal structure of common zoisite.* Amer. Min., 1935, vol. 20, pp. 106–111, 3 figs.

Common translucent zoisite from Prägratten, Tyrol, on the assumption that it is orthorhombic, gave a unit cell *a* 16·30, *b* 5·60, 0·21 Å. But the Laue pattern is similar to that of epidote with in repetition, and the crystal is really monoclinic with sub-microppic twinning. The unit cell is then *a* 8·92, *b* 5·60, *c* 10·21 Å., ntaining two molecules of $Ca_2Al_3(OH)(SiO_4)_3$, and isomorphous th epidote [M.A. **5**–324]. Fresh transparent zoisite may perhaps ve a different result. L. J. S.

LHMIAS (M. E.) & HÄGG (G.). *Bauxites et mullites, étudiées au moyen des rayons X.* (*Deuxième partie.*) Zeits. Krist., 1934, vol. 88, pp. 90–92. 4 figs. [Cf. M.A. **5**–473, **6**–60.]

Powder photographs, using Ca-K radiation, of bauxite calcined at 00° C. show that free silica is present in the form of tridymite. It suggested as the result of dilatation tests that the anomalous pansion curves of the various forms of crystalline silica are sensive to small amounts of impurity and are not to be relied upon for terminative purposes. Powder photographs using Cr-K radiation fibrolite and mullite are reproduced; the difference in the two tterns proves that the distinction between the two minerals is ll founded. F. A. B.

ARREN (B. E.) & AMBERG (C. R.). *X-ray study of narsarsukite,* $Na_2(Ti,Fe)Si_4O_{11}$. Amer. Min., 1934, vol. 19, pp. 546–548.

Taking the prism cleavage as (100), the tetragonal unit cell has mensions *a* 10·74, *c* 7·90 Å. (c/a = 0·735), and contains four molees of $Na_2(Ti,Fe)Si_4O_{11}$. The space-group and complete structure uld not be determined. L. J. S.

RNES (W. H.) & WENDLING (A. V.). *The space group of tourmaline.* Trans. Roy. Soc. Canada, 1933, ser. 3, vol. 27, sect. 3, pp. 169–175, 3 figs.

Green tourmaline of unknown locality gave *a* 15·85, *c* 7·07 Å. *a* 0·4464). The space-group is C_{3v}^1 (not C_{2v}^1). L. J. S.

ßNER (B.) & KRAUS (O.). *Über Kristallform und molekulare Einheit von Rinkit.* Centr. Min., Abt. A, 1933, pp. 369–374.

Rinkite from Greenland gave sp. gr. 3·458 and an orthorhombic l *a* 18·47, *b* 5·67, *c* 7·46 Å. containing two molecules $[SiO_4]_2[(Ti,$ $)F]Ca_2Na$. Comparison is made with zoisite and ardennite.

L. J. S.

Goßner (B.) & Kraus (O.). *Beitrag zur Kenntnis der Wöhlerit- und Mosandritgruppe.* Centr. Min., Abt. A, 1934, pp. 72–79.

The following cell dimensions were determined:

	a.	*b*.	*c*.	*β*.	
Wöhlerite	10·80	10·26	7·26 Å	71° 3′	
Låvenite	10·93	9·90	7·18	69 42	
Hiortdahlite	10·91	10·29	7·32	108 50	α 90° 29′ γ 90 8
Rinkite	18·47	5·67	7·46	88 47	
Mosandrite	18·37	5·63	7·42	(86 56)	

For the wöhlerite group the limiting formula is $(SiO_4)_2(ZrF)Ca_2Na$ [M.A. **5**-475]; in wöhlerite ZrF is partly replaced by NbO, in låvenite Ca_2 by Zr, and in hiortdahlite (ZrF)Na by Ca_2. These minerals bear no relation to the pyroxene group. For the mosandrite group the limiting formula is $(SiO_4)_2[(Ti,Ce)F]Ca_2Na$; in mosandrite and johnstrupite some (TiF)Na is replaced by Ca_2, and in rinkite some Ca_2 by Ce. L. J. S.

[Brunovsky (B. K.)] Бруновский (Б. К.). Исследование катаплеита рентгеновыми лучами.—Brunowsky (B). *Untersuchung des Katapleits mittels Röntgenstrahlen.* Труды Ломоносов. Инст. Акад. Наук СССР (Trav. Inst. Lomonossoff, Acad. Sci. U.R.S.S.), 1935, no. 6 (sér. cryst.), pp. 33–43 (Russ.), p. 44 (Germ. summary), 6 figs.

Soda-catapleiite from the Khibinsky tundra, Kola, has a hexagonal unit cell of dimensions *a* 7·39, *c* 10·05 Å. containing two molecules of $Na_2ZrSi_3O_9.2H_2O$. The calculated density is 2·743 and the space-group D^4_{6h}. L. J. S.

Gruner (John W.). *The structural relationship of nontronites and montmorillonite.* Amer. Min., 1935, vol. 20, pp. 475–483.

X-ray powder photographs of nontronite (including morencite, pinguite, faratsihite, stilpnochlorane, and chloropal) show broad and diffuse lines, but are in agreement with that of montmorillonite (bentonite). They are monoclinic structures with *a* and *b* averaging 5·23 and 9·06 Å., the distance between the layers ranging from 9·2 Å. at 575° C. to 15·8 Å. for moist material. Nontronite, beidellite, and montmorillonite form an isomorphous series with the structural formula $(OH)_8(Al,Fe''')_{8+n/3}(Si_{16-n},[Al,Fe''']_n)O_{40}.mH_2O$. In nontronite *n* ranges from 2 to 4 and in montmorillonite from 0 to 1; $m = 8-22$. L. J. S.

EHMEL (M.). *Über die Struktur von Halloysit und Metahalloysit.* Zeits. Krist., 1935, vol. 90, pp. 35–43, 3 figs.

Halloysite has a structure similar to but not identical with that kaolinite. Its space-group is C_s^3. The unit cell contains two lecules $H_4Si_2Al_2O_9$ and has a 5·20, b 8·92, c 10·25 Å., β 80°. The me applies to metahalloysite ($H_4Si_2Al_2O_9$), except that a 5·15, ·9, c 7·57 Å. H. H.

LACIOS (J.) & BARASOAIN (J. A.). *Estructura cristalina de la pirofilita.* Anal. Soc. Española Física y Química, 1934, vol. 32, pp. 271–274.

Pyrophyllite is monoclinic (pseudo-hexagonal) and has a unit cell dimensions a 5·20, b 9·06, c 18·29 A., β 84° 19′, containing 4 mols. $(OH)_2Si_4O_{10}$. The space-group is probably C_{2h}^3. L. J. S.

UNER (John W.). *The structures of vermiculites and their collapse by dehydration.* Amer. Min., 1934, vol. 19, pp. 557–575, 2 figs.

Vermiculite has a unit cell a 5·3, b 9·2, c 28·57–28·77 Å., β 82° 51′, taining four molecules $(OH)_2(Mg,Fe)_3(Si,Al,Fe)_4O_{10}.4H_2O$, and ace-group probably C_{2h}^5. The structure consists of $(OH)_4Mg_6(Si,)_8O_{20}$ sheets, like mica and talc, with interstratified layers (about Å. thick) of $8H_2O$. When the mineral is heated to 750° C. the ucture is almost identical with that of talc [M.A. **6**–45]. Hydrotite, representing a stage in the alteration of biotite to vermilite, consists of an interstratification of molecular layers of biotite d vermiculite with a different X-ray pattern. The term metastalline is suggested for such an arrangement. L. J. S.

EVERS (C. A.) & LIPSON (H.). *The crystal structure of copper sulphate pentahydrate, $CuSO_4.5H_2O$.* Proc. Roy. Soc. London, Ser. A, 1934, vol. 146, pp. 570–582, 1 pl., 5 text-figs.

The unit cell, a 6·12, b 10·7, c 5·97, contains two molecules; ace-group C_i^1. $4H_2O$ are arranged in a square around Cu and 2O mplete an approximate octahedron. The fifth H_2O is not co-dinated, but is in contact with 2O and $2H_2O$. L. J. S.

EVERS (C. A.) & SCHWARTZ (C. M.). *The crystal structure of nickel sulphate heptahydrate $NiSO_4.7H_2O$.* Zeits. Krist., 1935, vol. 91, pp. 157–169, 5 figs.

Nickel sulphate has the space-group V_4. The unit cell contains r molecules of $NiSO_4.7H_2O$ having a 11·8, b 12·0, c 6·80 Å. The rameters of Ni and S in the material were determined. H. H.

Lipson (H.) & Beevers (C. A.). *The crystal structure of the alums.* Proc. Roy. Soc. London, Ser. A, 1935, vol. 148, pp. 664–680, 1 pl., 6 text-figs.

Potash-alum has a 12·133 Å. and the unit cell contains 4[KAl$(SO_4)_2.12H_2O$]. Data are given for seven other alums. The space-group is T_h^6. The positions of the atoms are determined by Fourier analysis. The water has two positions: one set forms octahedral groups around Al; the other links together SO_4 tetrahedra, Al.$6H_2O$ octahedra, and K atoms. [Cf. M.A. **3**–431.] L. J. S.

Ramsdell (Lewis S.). *An X-ray study of the system K_2SO_4–$MgSO_4$–$CaSO_4$.* Amer. Min., 1935, vol. 20, pp. 569–574, 1 fig.

In the system K_2SO_4–$MgSO_4$ the only compound is $K_2Mg_2(SO_4)_3$ (langbeinite) with simple cubic structure and unit cell, a 9·96 Å., containing four molecules. Similarly, the system K_2SO_4–$CaSO_4$ has the compound $K_2Ca_2(SO_4)_3$ with a 10·37 Å. In the ternary system there is a complete isomorphous series of these two compounds, but no definite compound $K_2MgCa(SO_4)_3$. Polyhalite ($2CaSO_4.K_2SO_4.MgSO_4.2H_2O$) when dehydrated at 300° C. breaks down into $K_2MgCa(SO_4)_3$ and anhydrite. Brief calcination at 475° C. yields a porous product from which K_2SO_4 and $MgSO_4$ are readily extracted with hot water. L. J. S.

Watanabé (Tukonosuké). *The crystal structure of sulphohalite.* Proc. Imp. Acad. Tokyo, 1934, vol. 10, pp. 575–577, 1 fig.

Sulphohalite from Searles Lake, California, has a cubic unit cell of edge 10·15 Å. containing four molecules $2Na_2SO_4.NaCl.NaF$. The space-group is probably O^3 or O_h^5. The positions of the atoms can be worked out independently of X-ray data on the assumption that the sulphate groups form regular tetrahedra and that all the sodium atoms are structurally equivalent. [Cf. M.A. **6**–44.] L. J. S.

Keen (Richard C.). *The crystal structure of potassium persulfate $K_2S_2O_8$.* Zeits. Krist., 1935, vol. 91, pp. 129–135, 1 fig.

Potassium persulfate has the space-group C_i^1. The unit cell contains one molecule of $K_2S_2O_8$ and has a 5·10, b 6·83, c 5·40 Å., α 106° 54′, β 90° 10′, γ 102° 35′. H. H.

ßNER (B.) & BEßLEIN (J.). *Über kristallographische Beziehungen zwischen Silikaten und Phosphaten. Ein Beitrag zur Kenntnis des Beryllonites.* Centr. Min., Abt. A, 1934, pp. 144–151, 3 figs.

Beryllonite, previously described as orthorhombic, gave Lauegrams th pronounced monoclinic symmetry. The perfect cleavage is 10), and there is lamellar twinning on (101) and ($\bar{1}$01). The it ceil, a 8·13, b 7·76, c 14·17 Å., β near 90°, contains 12 mols. $BePO_4$; space-group C_{2h}^5. A close relation is shown with tri-rite, $(Mn,Ca)BeSiO_4$ [M.A. **3**–185]. L. J. S.

TTENLOCHER (H. F.). *Kristallstruktur des Aluminiumorthophosphates $AlPO_4$.* Zeits. Krist., 1935, vol. 90, pp. 508–516, 3 figs.

Aluminium phosphate has specific gravity 2·560 and refractive lices ϵ 1·530, ω 1·524. There is no cleavage. Its structure is very ilar to that of quartz. The unit cell contains three molecules of PO_4 and has edges a 4·93, c 2 × 5·47 Å. H. H.

BECK (Wolfgang). *Die Gitterkonstante[n] und Schmelzpunkte der Berzeliite.* Geol. För. Förh. Stockholm, 1934, vol. 56, pp. 525–530, 1 fig.

ECK (W.) & MACHATSCHKI (F.). *Die Kristallstruktur des Berzeliit $(Ca,Na)_3(Mg,Mn)_2[AsO_4]_3$.* Zeits. Krist., 1935, vol. 90, pp. 44–50.

Berzeliite has a structure isomorphous with garnet. The space-oup is O_h^{10}. The unit cell has a 12·35 Å. and contains eight mole-les of $(Ca,Na)_3Mg_2[AsO_4]_3$. The melting-point of magnesium-rzeliite is 1180°, and of manganese-berzeliite 1090°. H. H.

ACHATSCHKI (F.). *Die Kristallstruktur des Aluminiumarsenates $AlAsO_4$. Ein weiterer Beitrag zur Frage der Isomorphie von Kristallarten des Siliciums und fünfwertigen Arsens.* Zeits. Krist., 1935, vol. 90, pp. 314–321.

Aluminium arsenate is isomorphous with quartz and has a hexa-nal unit cell for which a 5·030, c 5·612 Å. H. H.

AULING (Linus), KLUG (H. P.), & WINCHELL (A. N.). *The crystal structure of swedenborgite, $NaBe_4SbO_7$.* Amer. Min., 1935, vol. 20, pp. 492–501, 3 figs.

New determinations on swedenborgite [M.A. **5**–321] gave a 5·47, 3·92 Å. with 2 mols. $NaBe_4SbO_7$ in the unit cell. Space-group

C_{6v}^4. Goniometric measurements gave $a : c = 1 : 1{\cdot}6308$. The positions of the atoms are fixed, the crystal containing octahedral SbO_6 groups, groups of four BeO tetrahedra with one corner common to all four, and large oxygen and sodium ions arranged in double hexagonal close packing. The mineral is considered as a basic salt of H_7SbO_6, and it shows a relation to basic beryllium acetate [M.A. **3**–435]. L. J. S.

Ehrenberg (H.) & Ramdohr (P.). *Die Struktur des Nordenskiöldins.* Neues Jahrb. Min., Abt. A, 1934, Beil.-Bd. 69, pp. 1–4, 2 pls., 1 text-fig.

Nordenskiöldine from Arandis, South-West Africa [M.A. **6**–46], has a hexagonal cell a 4·85, c 15·92 Å. ($c/a = 3{\cdot}282$), or a rhombohedral cell r 6·001 Å., α 47° 42′, containing one molecule $CaSnB_2O_6$. It has the same structure and very nearly the same dimensions as dolomite ($CaMgC_2O_6$). L. J. S.

Ziegler (G. E.). *Note on the unit cell and space group of KNO_2 and $LiNO_2.H_2O$.* Zeits. Krist., 1935, vol. 90, p. 95.

KNO_2 has probably the space-group C_s^3. The unit cell contains two molecules and has a 4·40, b 4·92, c 7·27 Å., β 65° 10′. $LiNO_2.H_2O$ has a monoclinic cell (pseudo-orthorhombic) containing four molecules and having a 3·31, b 14·10, c 6·36, β 75°. H. H.

Hendriks (Sterling B.). *The orientation of the oxalate group in oxalic acid and some of its salts.* Zeits. Krist., 1935, vol. 91, pp. 48–64, 5 figs.

The space-group, density, size of unit cell and number of molecules contained therein are tabulated for $H_2C_2O_4$ (two forms), $K_2C_2O_4.H_2O$, $Rb_2C_2O_4.H_2O$, KHC_2O_4, $RbHC_2O_4$, and $NaHC_2O_4.H_2O$. The structures (except for the last salt) are given in detail, the oxalate group being proved to have constant shape with coplanar atoms. The refractive indices are tabulated for the above substances together with $(NH_4)_2C_2O_4.H_2O$, $Na_2C_2O_4$, $CsC_2O_4.H_2O$, and $Li_2C_2O_4$. H. H.

Klug (Harold P.). *A study of the crystal structures of sym-diiodoethane and sym-diiodoethylene.* Zeits. Krist., 1935, vol. 90, pp. 495–507, 3 figs.

The substances *s*-$C_2H_4I_2$ and *s-trans*-$C_2H_2I_2$ are isomorphous with space-group C_{2h}^5, the unit cell containing two molecules. They approach closely to an orthorhombic symmetry in which the space-

coup is V_h^{18}, while the unit cell contains four molecules and as a 7·582, b 12·897, c 5·810 Å., and a 7·280, b 13·310, c 5·553 Å., spectively. H. H.

Miscellaneous.

HASHI (Ryōichi). *Chemical composition of the augite from Nishigataké, Japan.* (Japanese.) Journ. Geol. Soc. Tokyo, 1935, vol. 42, p. 201.

The augite previously described [Min. Mag. **19**–173] has been -analysed with the following results: SiO_2 51·66, TiO_2 0·33, Al_2O_3 05, Fe_2O_3 2·73, FeO 3·10, MnO 0·08, MgO 17·43, CaO 20·35, Na_2O 21, K_2O trace, H_2O 0·31 = 100·25, corresponding with $CaMgSi_2O_6$ 0·18, $CaFeSi_2O_6$ 10·69, $MgSiO_3$ 11·55, $NaFeSi_2O_6$ 1·57, or with diop- de 75·69, hedenbergite 11·67, clinoenstatite 12·64 %. R. O.

ORIANO GARCÉS (V.). *Sobre la morfologia del oligisto de Ojén.* Bol. Soc. Española Hist. Nat., 1932, vol. 32, pp. 305–308, 2 figs.

Measurement of crystals of haematite from Ojén, prov. Málaga, ve nine new forms with high indices, $\Phi(5.0.\bar{5}.16)$, &c. [$a:c = 1:$ 3623.] L. J. S.

ORIANO GARCÉS (V.). *Estudio de algunos minerales de espluga de Francolí (Tarragona).* Treballs Museu Ciènc. Barcelona, 1932, vol. 9, ser. min., no. 3, 26 pp., 12 figs.

A large block consisting mainly of niccolite with galena, calcite, d fluorite, shows crystals of native silver, argentite (new forms 150), $\lambda(350)$, $i(231)$, $\omega(134)$, $g(152)$, $x(156)$), hessite (twinned mono- inic crystals, $a:b:c = 0{\cdot}6883:1:0{\cdot}9966$, $\beta = 88°\,44'$), zinc-blende, illerite, chloanthite, pearceite (new forms $h(011)$, $g(312)$, $\epsilon(513)$), russite, and annabergite. L. J. S.

ARIĆ (Ljudevit). *Realgar od Lojana kod Kumanova.* Rad Jugoslav. Akad. Znanosti i Umjetnosti, Zagreb, 1934, vol. 249, pp. 95–103, 4 figs. (Croatian).

— *Der Realgar von Lojane bei Kumanovo.* Bull. Internat. Acad. Yougoslave Sci. Arts, Cl. Sci. Mat. Nat., 1934, vol. 28, pp. 21–23 (German summary).

In the Antonet antimony (stibnite) mine, near the chromite deposit Lojane in Serbia, massive realgar contains small prismatic crystals cavities. Measurement of these showed 27 crystal-forms of which 141), $\theta(\bar{1}91)$, $\pi(231)$ are new. [$a:b:c = 0{\cdot}7203:1:0{\cdot}4858$, $\beta = 66°$ ′.] L. J. S.

Jakob (J.), Friedlaender (C.), & Brandenberger (E.). *Über Neubildung von Sericit.* Schweiz. Min. Petr. Mitt., 1933, vol. 13, pp. 74–83, 1 pl.

A pale-green, plastic, clayey material fills narrow veins in weathered gneiss near Albbruck, Baden. It consists of minute (0·02 × 0·08 mm.) idiomorphic crystals of quartz and fine scales (0·001 mm.) of sericite. The latter has α 1·560, γ 1·578, and gives the X-ray pattern of typical sericite; analysis gave SiO_2 50·05, TiO_2 0·14, Al_2O_3 30·11, Fe_2O_3 1·47, FeO 0·43, MnO 0·01, MgO 2·49, CaO nil, Na_2O 1·97, K_2O 9·80, H_2O+ 3·58 = 100·05. L. J. S.

Meyer (Dorothy Babcock). *A sericite of unusual composition.* Amer. Min., 1935, vol. 20, pp. 384–388, 1 fig.

A conglomerate at Pilot Knob, Ironton, Missouri, contains nodules, suggesting altered pebbles, of a soft greenish mineral with a greasy feel, which has been usually described as steatite. Analysis gave SiO_2 47·30, Al_2O_3 36·31, Fe_2O_3 2·17, Na_2O 5·27, K_2O 2·70, H_2O 5·80 = 99·55, corresponding with $(H,K,Na)_2O.(Al,Fe)_2O_3.2SiO_2$. Although containing an excess of soda, the mineral is distinct from paragonite. Most of the water is lost at 450–600° C., and the dehydration curve resembles that of kaolin. Sp. gr. 2·69, n 1·580, X-ray pattern like that of sericite. L. J. S.

Bjørlykke (Harald). *Norwegische Mikrolithmineralien. Ein Vorkommen von Mikrolith in Iveland, Setesdal, s. Norwegen.* Norsk Geol. Tidsskrift, 1934, vol. 14, pp. 145–161, 2 figs.

Brown-black crystals ($o\,d\,n$) of microlite in cleavelandite-quartz-pegmatite from Landås gave Ta_2O_5 73·72, Nb_2O_5 very little, TiO_2 1·58, UO_2 4·21, Ce_2O_3 &c. 0·50, FeO 2·77, MgO 0·34, CaO 10·48, Na_2O 3·26, K_2O 0·64, H_2O+ 0·39, H_2O- 2·33 = 100·22; sp. gr. 5·82; formula $X_2Z_2(O,OH)_7$ [M.A. **5**–185]. X-ray spectral analysis showed the presence of several rare-earths, and X-ray powder photographs gave a unit cell of edge a 10·364 Å. A microlite-like mineral in ijolite-melteigite from the Fen district, Telemark, is probably koppite, with a 10·415 Å. Ellsworthite from Hybla, Ontario, gave a 10·281 Å. L. J. S.

Lupander (Kurt). *Ljusbrytning och specifik vikt hos kiselgur.* Geol. För. Förh. Stockholm, 1934, vol. 56, pp. 521–524.

Kieselguhr (diatomite) from various localities in Finland gave d_2 1·985–2·010, n_D 1·4409–1·4413. L. J. S.

ASZKIEWICZ (Antoni). *Glazeryt i syngenit ze Stebnika.—La glaséri*
et la syngénite de Stebnik. Arch. Min. Tow. Nauk. Warszaw
(Arch. Min. Soc. Sci. Varsovie), 1934, vol. 10, pp. 117–120
(Polish), p. 121 (French résumé), 1 fig.

Aphthitalite (= glaserite) has recently been found in the salt mine
Stebnik, Poland. It forms prismatic crystals with hexagonal
bit, owing to the equal development of the positive and negative
ombohedra; forms $macrr'ee'$. Measurements agree best with
$c = 1 : 1{\cdot}2879$ (H. Bücking, 1889). X-ray powder photographs
ve a 5·635, c 7·27 Å. Analysis, SO_4 57·47, Cl 0·025, Ca 0·10, Mg
ace, K_2O 34·31, Na_2O 7·36, H_2O 0·09, insol. 0·41, corresponds with
·67 % $3K_2SO_4.Na_2SO_4$. Crystals of syngenite flattened on (100)
ow the forms $amλθcqur$ [M.A. **3**–549]. L. J. S.

RCHERT (Hermann). *Über Entmischungen im System Cu-Fe-S und*
ihre Bedeutung als „geologische Thermometer". Chemie der
Erde, 1934, vol. 9, pp. 145–172, 2 pls., 12 text-figs.

At 235° C. cubanite breaks down to chalcopyrite and chalcopyr-
otine (CuS.4FeS); the latter is stable between 255° and 450° or
0°, and on slow cooling it breaks down into pyrrhotine, cubanite
valleriite, and chalcopyrite. Over 450° or 550° chalcopyrrhotine
rms mixed crystals with chalcopyrite or pyrrhotine. L. J. S.

ARREN (Harry V.) & LORD (Clifford S.). *An occurrence of schwatzite*
in British Columbia. Econ. Geol. Lancaster, Pa., 1935, vol. 30,
pp. 67–71.

Massive tetrahedrite with silvery white to grey colour and dark
ldish-brown streak, from West Kootenay mine, Windermere dis-
ict, gave on partial analysis Sb 23·4, As 1·4, Cu 33·8, Ag 0·2, Zn
), Pb nil, Fe 1·0, Hg 6·1, S 22·1, insol. 4·9 = 96·9; sp. gr. 4·83.
trahedrite from other mines in the district contains no mercury.
L. J. S.

OODSPEED (G. E.). *Tellurides at Cornucopia.* Engin. & Mining
Journ. New York, 1935, vol. 136, pp. 72–73, 4 figs.

Most of the quartz veins in NE. Oregon contain small and sporadic
nounts of tellurides associated with native gold, pyrite, chalcopyrite,
nc-blende, calcite, &c. Petzite is the commonest species and syl-
nite has also been recorded. L. J. S.

Laudermilk (J. D.). *Soda-alunite from Molokai, Hawaiian Islands.* Amer. Min., 1935, vol. 20, pp. 57–58.

White, chalky material composed of minute rhombohedra, from basalt, gave SO_3 37·02, TiO_2 0·60, Al_2O_3 34·64, Fe_2O_3 2·16, MgO trace, CaO 0·28, Na_2O 4·62, K_2O 6·08, SiO_2 0·04, P_2O_5 nil, H_2O 15·38 = 100·82, and other elements detected spectroscopically. L. J. S.

Heineman (Robert E. S.). *Sugarloaf Butte alunite.* Engin. Mining Journ. New York, 1935, vol. 136, pp. 138–139, 2 figs.

White, porcellaneous alunite fills irregular branching veins in dacite at Sugarloaf Butte near Quartzsite, Yuma Co., Arizona. The dacite contains pyrite, and in the oxidized zone haematite. A partial analysis of the alunite gave SO_3 38·1, Al_2O_3 36·5, K_2O 4·85, Na_2O 4·3, SiO_2 1·2. The veins are fissure veins and the occurrence is similar to that at Marysvale, Utah. L. J. S.

Thibault (Newman W.). *Celestite from Chittenango Falls, New York.* Amer. Min., 1935, vol. 20, pp. 147–152, 2 figs.

Small crystals of celestine from geodes in dolomitic limestone gave α 1·622, β 1·624, γ 1·632, sp. gr. 3·968, 3·939. They contain no barium and only little calcium. Goniometric measurement gave $a : b : c = 0{\cdot}7812 : 1 : 1{\cdot}2834$; forms $c\ o\ m\ z\ d\ l\ \Phi\ \sigma\ y\ g\ b\ v$ [Dana's letters], and new Δ_1 (109), Σ (1.0.11), (3.0.29) ?, (3.0.31) ? L. J. S.

Milton (Charles). *Jarosite in tuff from Potosi, Bolivia.* Amer. Min., 1935, vol. 20, pp. 176–178, 2 figs.

A bedded volcanic tuff with Pliocene plant remains contains microscopic crystals of jarosite disseminated through the entire rock, and also concentrated in brownish-yellow bands. Analysis of the portion of the tuff soluble in HCl shows that about 16 % of jarosite is present. L. J. S.

Conant (L. C.). *Optically positive cordierite from New Hampshire.* Amer. Min., 1935, vol. 20, pp. 310–311.

Porphyritic granite at Stoddard, Cheshire Co., contains scattered inclusions and is of several types (probably from assimilation of roof material) in some of which cordierite is associated with garnet or fibrolite. Optically positive cordierite has been previously recorded only from India and North-West Territories in Canada [Min. Mag. **20**–248, **22**–121; M.A. **1**–66, **5**–384]. L. J. S.

NN (James H.). *Note on the occurrence of vivianite in the District of Columbia.* Amer. Min., 1935, vol. 20, pp. 311–312.

Small, globular or root-like nodules of blue vivianite have been nd associated with limonite in excavations in sandy clay in the y of Washington. L. J. S.

MSTRONG (E. J.). *Schroeckingerite from Bedford, New York.* Amer. Min., 1935, vol. 20, pp. 62–63.

Minute laths on pegmatite gave extinction 30°, 2V 40–45°, negative, h very strong crossed dispersion; α 1·658, β 1·682, γ 1·685. L. J. S.

LFELD (Friedrich), HIMMEL (Hans), & SCHROEDER (Robert). *Beiträge zur Kenntnis bolivianischer Mineralien. III. Zinnkies.* Zentr. Min., Abt. A, 1935, pp. 161–169, 10 figs.

Several complex twinned crystals of stannite are described in ail from Oruro, Potosi, Chocaya, and Huanuni, Bolivia. New ms w (130), v (120), x (031); $a : c = 1 : 0{\cdot}9833$. Twinning on (101) (111), but regular pseudo-cubic forms (as in Min. Mag. **13**–581) re not found. L. J. S.

LFELD (Friedrich), HIMMEL (Hans), & KLEBER (Willi). *Beiträge zur Kenntnis bolivianischer Mineralien. IV. Teallit.* Zentr. Min., Abt. A, 1935, pp. 225–231, 4 figs.

Measurement of thin tabular crystals occurring with wurtzite at illos Mt., near Carguaicollo, dep. Potosi, gave $a : b : c = 0{\cdot}971 : 1 : 35$, and the forms c (001), M (110), f (011), C (305), B (405), (101), e (201), o (111), p (221). L. J. S.

NDES (Kenneth K.). *The beryl-molybdenite deposit of Chaffee County, Colorado.* Econ. Geol. Lancaster, Pa., 1934, vol. 29, pp. 697–702.

A quartz vein in quartz-monzonite at California mine, Brown's ek, has yielded some molybdenite. Associated minerals are beryl me gem quality aquamarine), sericite, and molybdite. The sence of beryl suggests a connexion with the pegmatite veins from neighbouring mass of granite of Mt. Antero. L. J. S.

ßNER (B.) & REINDL (E.). *Über die chemische Zusammensetzung titanhaltiger Silikate, insbesondere von Astrophyllit.* Centr. Min., Abt. A, 1934, pp. 161–167.

A specimen of 'schorlomite' (sp. gr. 3·804) from Magnet Cove, kansas, gave analysis I, showing that it does not differ from lanite. A garnet richer in titanium, to determine the relation of

Ti and Si, could not be obtained. Astrophyllite from Låven, Norway, sp. gr. 3·385–3·421, gave analysis II corresponding to $[Si_2O_7]_2[(Ti,Zr)(OH,F)_2](Fe,Mn)_4(K,Na)_2$. Taking the perfect cleavage as (001) and the optic axial plane as (100), the unit cell has dimensions a 11·70, b 5·40, c 21·10 Å. ($a:b:c = 2·176:1:3·907$), and contains four of the above molecules; but it is pseudo-orthorhombic, and either monoclinic or triclinic.

	SiO_2.	TiO_2.	ZrO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.	Total.
I.	34·38	4·39	0·30	1·92	23·46	1·68	0·31	0·80	33·19	100·43
II.	33·81	8·02	5·34	1·72	4·36	16·58	15·18	0·63	1·16	100·23

II, also Na_2O 3·18, K_2O 6·12, H_2O 3·43, F 0·70.

L. J. S.

Kawano (Yoshinori). *Chemical formula of basaltic hornblende.* Proc. Imp. Acad. Tokyo, 1934, vol. 10, pp. 349–352.

Basaltic hornblendes previously described [M.A. **5**–349] gave analyses I, from Yôdôdô, Korea; II, from Lukow, Bohemia, corresponding to the formulae:

I, $(O,OH,F)_{2·0}(Ca,Na,K)_{2·8}(Mg,Fe'',Mn,Fe''',Ti)_{5·1}[(Si,Al)_{4·0}O_{11·0}]_2$

II, $(O,OH,F)_{2·0}(Ca,Na,K)_{3·1}(Mg,Fe'',Mn,Fe''',Al,Ti)_{5·0}[(Si,Al)_{4·0}O_{11·0}]_2$.

In the high percentage of TiO_2 no. I approaches kaersutite. The unit cell of no. I, a 9·77, b 17·85, c 5·32 Å., β 73° 58′, contains two molecules.

	SiO_2.	TiO_2.	Al_2O_3.	Fe_2O_3.	FeO.	MnO.	MgO.	CaO.	Na_2O.	K_2O.	H_2O.+
I.	38·30	6·06	12·87	7·98	6·96	0·12	11·79	10·47	3·11	1·30	1·10
II.	39·20	4·40	14·72	8·96	1·10	0 06	13·81	12·08	2·80	2·14	0·98

I, also H_2O- 0·62, F 0·05, total 100·71. II, also H_2O- 0·40, F 0·06, total 100·68.

L. J. S.

Chudoba (K.) & Schilly (W.). *Die Morphologie des Magnetits in Abhängigkeit vom strukturellen Aufbau.* Neues Jahrb. Min., Abt. A, 1934, Beil.-Bd. 68, pp. 241–267, 4 figs.

Discussion of the crystal-forms and zones of magnetite and their relation to the internal structure. L. J. S.

Goldschmidt (Victor) [1853–1933] & Müller (Karl). *Augit vom Vesuv. Teil I. Zwillingsgesetze.* Neues Jahrb. Min., Abt. A 1934, Beil.-Bd. 68, pp. 195–222, 1 pl., 21 text-figs.

A large series of isolated crystal intergrowths of augite from Vesuvius are grouped according to the twin-laws. These include twins ('homo-twins') on a(100), $W(\bar{1}22)$, y(101), $s(\bar{1}11)$, and doubtfully on c(001), those on m and s being new. In addition, a large

mber of 'hetero-twins', in which there is parallelism of one face d one edge in the two individuals, is listed. A number of possible es is 161. L. J. S.

WLEDGE (H. P.). *A new method for the determination of ferrous iron in refractory silicates.* Journ. Roy. Soc. Western Australia, 1934, vol. 20 (for 1933–1934), pp. 165–199.

The mineral is fused with sodium metafluoborate $(NaF)_2B_2O_3$ in a lled pyrex glass tube, the fusion dissolved in dilute H_2SO_4, and rated with $KMnO_4$. Almandine by this method gave Fe_2O_3 1·77, O 31·69 % (against Fe_2O_3 3·31, FeO 30·30 % by the unsatisfactory $F + H_2SO_4$ method) showing better agreement with the garnet rmula. Analyses by the two methods were also made of biotite, urolite, axinite, and tourmaline from Western Australian localities. review is given of the various methods for the analysis of refractory cates, and various other fluxes were tested, but $(NaF)_2B_2O_3$ gave best results. L. J. S.

RPENTER (*Sir* Harold). *Native iron from west Greenland.* Nature, London, 1935, vol. 136, pp. 152–153, 6 figs.

Analysis of iron from Ovifak, Disco Island, gave Fe 93·9, Ni 2·50, 0·98, Cu 0·21, C 1·63, SiO_2 0·24. This is lower in nickel and gher in carbon than meteoric iron. Polished and etched sections ow no Widmanstätten structure; but patches and bars of a white nstituent (cementite, which is stained brown by a boiling alkaline ution of sodium picrate) in a finely divided duplex matrix (eutec- d of ferrite and cementite). This iron is a high-carbon nickel- balt steel. Such a structure has not been formed by solidification m the liquid state, but probably by the action of carbon or carbon noxide on metal at about 900° C. The metal itself may have en produced by the reduction of iron oxide by the gas, and then rburized. L. J. S.

LLITELLI (Paolo). *Il quarzo di Baveno.* Periodico Min. Roma, 1935, vol. 6, pp. 105–128, 4 figs.

A detailed crystallographic description. Sixty-four crystal-forms e noted, including new $(30.\bar{4}.9)$, $(37.\bar{1}\bar{4}.7)$, $(30.\bar{1}\bar{4}.7)$, $(30.\bar{9}.\bar{4})[a : c = 1·09997]$. L. J. S.

Peacock (M. A.). *Topaz from Devil's Head, Colorado.* Amer. Min., 1935, vol. 20, pp. 354–363, 12 figs.

Cavities ($4 \times 2 \times 1$ feet) in pegmatite at Devil's Head [Douglas Co.] contain crystals of topaz, smoky-quartz, microcline, albite, and rarely fluorite and cassiterite. The topaz crystals, up to 8 cm. across, are colourless or iron-stained and show fourteen crystal-forms and etch-figures. L. J. S.

Schoklitsch (Karl). *Beitrag zur Physiographie steirischer Karbonspäte. (Gitterkonstanten, physikalische Angaben und chemische Zusammensetzung.)* Zeits. Krist., 1935, vol. 90, pp. 433–445, 4 figs.

Tables are given of the density, refractive index, crystallographic structure, &c., of calcite, dolomite, ankerite, magnesite, breunnerite, and chalybite from several localities in Styria. H. H.

Himmel (H.) & Schroeder (Robert). *Sardinian = Anglesit.* Zentr. Min., Abt. A, 1935, pp. 114–116, 2 figs.

Measurement of crystals from the original material described by A. Breithaupt (1866) as sardinian, from Monteponi, Sardinia, definitely proves their identity with anglesite. L. J. S.

Keller (W. D.). *The occurrence of mendozite and tamarugite in Missouri.* Amer. Min., 1935, vol. 20, pp. 537–539.

A white powdery efflorescence on dolomite near Eureka consists of a mixture of mendozite [$NaAlS_2O_8.11H_2O$] and tamarugite [$NaAlS_2O_8.6H_2O$]. The former has n 1·490 with low birefringence, and the latter recrystallized from water gave α 1·436, β 1·455, γ 1·459, 2V 40–50°, negative. L. J. S.

Donnay (J. D. H.). *Morphologie des cristaux de calavérite.* (Communication préliminaire.) Bull. Soc. Géol. Belgique, 1935, vol. 58, pp. B 222–B 230.

The complex form relations of calaverite [M.A. **5**–205] are explained by a gliding or translation of the lattice giving a new type of twinning. L. J. S.

Preston (Eric) & Turner (W. E. S.). *A note on the volatility of silica.* Journ. Soc. Glass Technology, Sheffield, 1934, vol. 18, pp. 222–224, 1 pl.

Silica is not volatile in air at temperatures up to 1400° C. A small volatility at temperatures above 1400° C. in an atmosphere of steam is assigned to chemical action; the steam is partially dissociated, and the silica is alternately reduced and reoxidized. M. H. H.

MINERALOGICAL SOCIETY PUBLICATIONS

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